CONSTRUCTION STANDARD SPECIFICATION
SECTION 15810
DUCTWORK

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PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: This specification, in conjunction with the contract documents and design drawings, provides the minimum requirements for materials and operations used in the fabrication and installation of ductwork. Systems covered by this document include heating, ventilating, air conditioning and exhaust for pressure classes from minus 10 inches to plus 10 inches water gauge. Operations include the specification of ductwork materials, gauges, pressure classifications, construction, duct liners, filters, dampers, connectors, supports, testing and certifications. This specification does not include ductwork requirements for materials handling systems. The materials, products, accessories, and methods listed in this specification shall be followed unless noted otherwise on the drawings. All work performed under this specification shall conform to Section 15050, "Basic Mechanical Materials and Methods."

1.02 REFERENCES

A. The latest edition of the following codes and standards shall be used. Where differences between Standards and this specification exist, this specification shall take precedence. Where Standards allow for the use alternate materials and methods, the contractor shall submit for approval a request to use alternate materials and methods before beginning work.

B. Sheet Metal And Air Conditioning Contractors' National Association (SMACNA)

HVAC Duct Construction Standards - Metal and Flexible
HVAC Duct Systems Design
Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
Accepted Industry Practice for Industrial Duct Design
HVAC Systems - Testing, Adjusting and Balancing
Round Industrial Duct Construction Standards
Rectangular Industrial Duct Construction Standards
HVAC Air Duct Leakage Test Manual.

C. National Fire Protection Association (NFPA)

80 Standard for Fire Doors and Windows
90A Standard for Installation of AC and Ventilation Systems
90B Standard for Installation of Warm Air Heating and AC Systems
255 Building Materials, Test of Burning Characteristics (same as ASTM E84)

D. American Society for Testing and Materials (ASTM)

A240 Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
A480 Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip
A653 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process
C916
C1071
E84 Standard Test Method for Surface Burning Characteristics of Building Materials
E477 Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers
E814 Standard Test Method for Fire Tests of Through Penetration Fire Stops

E. American Welding Society (AWS)

B2.2 Brazing Procedures and Performance Qualifications
D9.1 Sheet Metal Welding Code

F. Underwriter's Laboratories (UL)

181 Factory Made Air Ducts and Air Connectors
555 Standard for Safety Fire Dampers
555S Leakage Rated Dampers for Use in Smoke Control Systems
723 Test for Surface Burning Characteristics of Burning Materials (ASTM E84)

G. North American insulation Manufactures Association (NAIMA

AH124 Fibrous Glass Duct Liner Standard

1.03 SUBMITTALS

General: Manufacturers, products and model numbers cited in this specification are meant to serve as a guide to minimum standards set forth by this specification. Proposed substitutions that can meet these minimum standards are allowed for submittal, and shall be included in the submittal package furnished to the Sandia Delegated Representative (SDR) for consideration and approval, prior to commencement of work. Submittals shall conform to Section 01330, “Submittal Procedures."

A. Shop Drawings: Submit shop drawings for the following items:

1. Plenums and plenum related items showing physical dimensions, joints, sealants, door construction and hardware.
2. Factory fabricated ducts, fittings and joining systems.
3. Firewall duct penetrations; fire and smoke dampers; louvers and access doors.

B. Submit Material Safety Data Sheets on sealants and adhesives.

C. Submit changes or alterations in ductwork layout, with supporting calculations showing that the modified design will not increase total pressure, before work commences. Submittals for proposed changes shall be stamped for approval prior to commencement of work.

D. Submit control-wiring diagrams for automatic dampers and other automated ductwork accessories.

E. Duct Coordination Drawings (Duct Shop Drawings): When required on the Descriptive Submittal List, the contractor shall submit ¼ inch or 1/8 inch scale plan drawings of duct work layout with overlays of other major systems, structures, and equipment that could interfere with the routing of the ductwork. Include reflected ceiling layout, ceiling and wall mounted access doors and panels required to provide access to dampers and other operating devices, and ceiling mounted items including light fixtures, diffusers, grills, speakers, and sprinklers. Include elevation sections through congested areas. Base input on information from installers of items involved and when possible field verify obstacles to the duct layout.

F. Ductwork Reinforcement Information: When required by the Descriptive Submittal List or requested by the Sandia Construction Observer (SCO), submit information on the duct reinforcement to be used for each section of duct. Information shall include copies of tables from SMACNA construction standards highlighting the actual duct sizes, pressure class, material, gauge, reinforcement type and spacing, joint type and spacing, applied loads, and hanger type and spacing. When alternated methods of sizing are used as provided by SMACNA, provide calculations to support the reinforcement selection.

G. Alternative Materials and Methods: Proposed deviations of materials and methods from these specifications require approved submittal information prior to any construction. Submittals should clearly note that the submittals is for a change to the specifications and identify the applicable paragraph from this specification. Submittals shall include physical descriptions and results of testing and analysis to support the equal performance of the substituted items. Testing and analysis shall follow the guidelines for “Functional Criteria from SMACNA standards.

1.04 QUALITY ASSURANCE

A. Employ qualified sheet metal workers in accordance with SMACNA Duct Construction Standards.

B. Asbestos Free: Insulating and sealing materials must be certified to be free of asbestos.

C. Brazing: Certify brazing procedures, brazers, and operators in accordance with AWS B2.2 Brazing Procedures and Performance Qualifications.

D. Welding: Certify welding procedures, welding equipment and welders in accordance with AWS D9.1 Sheet Metal Welding Code.

E. Attachments, such as conduit and pipe, to ductwork are not permitted.

1.05 WARRANTY

A. Ductwork system components furnished under this contract shall be guaranteed against defective design, materials, and workmanship for the full warranty period, which is standard with the manufacturer or supplier, but in no case less than one year from the date of system acceptance.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

A. Rigid Ducts, Casings and Fittings: Shall be made from galvanized steel sheets of lock form quality per ASTM A653 with a G90 zinc coating (0.90 oz/ft^2 both sides), unless otherwise shown on the contract documents. Sheets shall be free of pits, blisters, slivers, and ungalvanized spots.

B. PVC Coated Rigid Ducts, Casings and Fittings: Shall be made from galvanized steel sheets of lock form quality per ASTM A653 with a G60 zinc coating (0.60 oz/ft^2 both sides), unless otherwise shown on the contract documents. Provide with factory applied 4-mil PVC coating on exposed surfaces (exterior of duct for underground applications and interior of ducts and fittings for fume handling) and 2-mil coating on opposing sides of ductwork. Ductwork shall be UL-181, Class 1 listed.

C. Stainless Ductwork: Unless noted otherwise on the drawings, stainless steel ductwork shall be Type 316L steel sheet per ASTM A480 and ASTM A240 with a finished surfaced No. 4 for exposed locations, and No. 2B for concealed locations. When 'Welded Duct' is called out on the drawings, ducts shall be have longitudinally welded seams and welded or flanged joints and connections to equipment or accessories.

D. Supports: Angle iron, channels, rods and related supporting materials shall be galvanized or red oxide coated.

E. Fasteners: Use galvanized rivets, screws and bolts throughout, except on stainless steel ductwork, use SS fasteners.

F. Reinforcement: Provide galvanized steel or stainless steel reinforcement shapes and plates where required.

G. Tie Rods: Use galvanized steel, 1/4 inch minimum diameter fasteners for ductwork 36 inch or less in length; use 3/8 inch minimum diameter for lengths longer than 36 in.

H. Flexible Duct - Supply & Return Air (Insulated, Low Pressure): Duct to be a factory fabricated assembly with a laminated inner liner of aluminum foil, fiberglass and polyester, a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket. Flexible duct shall be rated for 6.0" w.g. positive pressure, 4.0" w.g. negative pressure thru 16" diameter, 4000 FPM velocity, -20 to 250 deg. F operating temperature, 0.1 perm rating, and have a maximum thermal conductance of 0.23 BTUH/Hr-Deg F. Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less. Flexible duct shall be tested in accordance with UL 181 and listed and labeled as Class 0 or Class 1. Flexmaster Type 5 or equal.

I. Flexible Duct - Supply & Return Air (Insulated, High Pressure): Duct to be a factory fabricated assembly with a laminated inner liner of aluminum foil, fiberglass and polyester, a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket. Flexible duct shall be rated for 12.0" w.g. positive pressure, 5.0" w.g. negative pressure thru 16" diameter, 5500 FPM velocity, -20 to 250 deg. F operating temperature, 0.1 perm rating, and have a maximum thermal conductance of 0.23 BTUH/Hr-Deg F. Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less. Flexible duct shall be tested in accordance with UL 181 and listed and labeled as Class 0 or Class 1. Flexmaster Type 3 or equal.

J. Flexible Duct – Lab Exhaust Systems: Ductwork to be a factory fabricated assembly of neoprene-coated polyester with galvanized steel helix reinforcement. Flexible duct shall be rated for a minimum of 6.0" w.g. positive pressure, 4.0" w.g. negative pressure, 5500 FPM velocity, -65 to 250 degrees F. Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less. Uni-flex Model U-LOK 200 or equal.

K. Mechanical Liner and Fasteners:

1. Liners: Internal duct liners shall be 1 inch thick fiberglass Type I or II per ASTM 1071 and have a thermal conductivity (k-value) of 0.26 at 75 deg. F. Liners shall comply with NFPA 90A and 90B and with NAIMA AH124 and have a maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84. Liners shall be treated with an EPA approved biocide to resist bacterial and fungal growth. All surfaces exposed to the air stream shall be coated to prevent erosion of glass fibers.

2. Mechanical Fasteners: galvanized steel, suitable for adhesive, mechanical or welding attachment (self-stick adhesive fasteners are not permitted). Provide fasteners that will not damage the liner when applied as recommended by the manufacturer, that do not cause leakage within the duct and that will sustain a 50-pound tensile dead load perpendicular to duct wall.

3. Liner Adhesive: Non-oxidizing, vinyl acrylic, water-based adhesive used to bond insulation to sheet metal surfaces. Operational temperature range -20 to +160°F; curing time 24 hours. Manufactured by United McGill, type Uni-Tack. Comply with NFPA 90A and 90B and with ASTM C916

2.02 DESIGN AND CONSTRUCTION

A. General:

1. Construct all ducts, casings and fittings of rigid, galvanized steel, unless otherwise shown in the contract documents.
2. Contractor is responsible for coordination between the ductwork trade and the other mechanical, electrical and architectural trades.
3. Insulation shall be as specified in Section 15081, "Duct Insulation."
4. Install internal duct liners on ducts indicated to have liners on the construction drawings. Install liners per NAIMA duct liner guidelines.

B. Ductwork Pressure Classification

Unless otherwise indicated on the construction drawings, ductwork shall be constructed to meet the appropriate pressure class defined below.

1. Ductwork from the supply air fan to the terminal velocity reduction device (VAV box) or zone-tempering coil shall be fabricated to meet minimum 4" w.g. internal pressure.
2. Ductwork from downstream of terminal velocity reduction device (VAV box) or zone tempering coil shall be fabricated to meet minimum 1" w.g. internal pressure.
3. Return air ductwork shall be fabricated to meet minimum 1" w.g. internal pressure.
4. Lab exhaust ductwork shall be fabricated to meet the lower of either 4" w.g. negative pressure, or the exhaust fan pressure at shut-off.
5. Restroom exhaust and general exhaust ductwork shall be fabricated to meet the lower of either 2" w.g. negative pressure, or the exhaust fan pressure at shut-off.
6. Acid resistant ductwork (PVC coated) shall be fabricated to meet 3" w.g. on supply ducts and negative 2" w.g. on return and exhaust ducts.

C. Plenums:

1. Main air handling (equipment) plenum walls, doors, and roof shall be factory built as follows: 18 gauge galvanized steel, minimum, double-wall construction (perforated inner walls) 4 inch acoustical insulated casing (top and sides) to provide a "U"-value of 0.06 Btu/hr-ft²-°F, hinged access doors with 90° latching handles to all compartments (double-wall insulated doors with air-tight sealing gaskets). Doors shall be provided with 12”x12” double pane, hermetically sealed observation windows of wire-reinforced glass. Panels shall be provided with (end, bottom or top) supply and return duct openings, as shown on the drawings; return air and outside air dampers shall be furnished where indicated. Interior partition walls shall be perforated 20 gauge steel

acoustic panels sandwiching 4" minimum thickness, 1.5 lb/cu.ft. rigid fiberglass insulation, reinforced to be rigid under all operating conditions.

2. All other plenums shall be factory or site built of 16 gauge galvanized metal panels. Maximum width of panel shall be 21". One end of panel shall be flanged 1" and opposite end formed with 1" double standing seam.

D. Rectangular Ductwork: Shall conform to SMACNA HVAC Duct Construction Standards, Metal and Flexible or SMACNA Rectangular Industrial Duct Construction Standards, except:

1. Addendum No. 1 (November 1997) covering Midpanel Tie Rod use shall not be used.

2. Construct ducts using Pittsburgh Lock or Double Corner seams except Snap Lock seams may be used for pressure classes of 2 inch or less.

3. Cross-Breaking:

   a. Sheet metal ducts and fittings over 18 inches shall be cross-broken; or otherwise stiffened to eliminate oil canning or vibration.
   b. Vertical and horizontal sheet metal barriers, duct offsets, and elbows shall be cross-broken.
   c. Cross-breaking shall be applied to the sheet metal between the standing seams or reinforcing angles; the center of cross-break shall be of the required height to assure surfaces being rigid.

4. Radius Elbows: Radius elbows with a rectangular cross section shall have a centerline radius of not less than the width of the duct or shall be furnished with single thickness splitter vanes. A single splitter vane shall be used for elbows with a ratio of inside radius to duct width of 0.5 to 0.2. Two splitter vanes shall be used for ratios less that 0.20.

5. Square Elbows: Square elbows shall be equipped with either single or double thickness turning vanes with a radius of 4.5”, and a separation of 3.25”, pre-assembled on runners constructed per SMACNA Accepted Industry Practice for Industrial Duct Design. Vanes shall be securely attached to the runners. Vanes shall be welded to the runners in systems with pressures greater than 6” w.g. or velocities greater than 3000 FPM. The maximum unsupported length of vanes shall be 36”.

E. Round Ductwork:

1. Spiral lockseam or longitudinal welded seam as manufactured by United McGill Sheet Metal Company. Models Uniseal, Unicoat, or Longitudinal Seam.

2. Minimum galvanized steel or stainless steel gauges, hanger spacing, and reinforcement shall be per SMACNA HVAC Duct Construction Standards - Metal and Flexible for pressures from negative 4” w.g. up to positive 10” w.g. For pressures less than negative 4” w.g., or greater than positive 10” w.g.,

minimum galvanized steel or stainless steel gauges, hanger spacing, and reinforcement shall be per SMACNA Round Industrial Duct Construction Standards.

3. Fittings: Fittings shall have a wall thickness not less than that required for longitudinal-seam straight duct.

4. Elbows:

   a. Elbows for round ducts shall have a minimum centerline radius of 1-1/2 times the diameter of the duct and shall be constructed without splitters.
   b. Smooth or stamped elbows shall be used whenever possible.
   c. When gored elbows are used they shall be constructed as follows: Elbows up to 36° shall have 2 gores, 37° through 72° shall have 3 gores, and 73° through 90° shall have 5 gores.
   d. Four gore adjustable elbows are permitted for systems rated at 1 in. w.g. or less. The gores shall be tack welded or coated with sealer on diameters from 8" to 14". Diameters above 14" shall be tack welded.

F. Flat Oval Ductwork: Ductwork and fitting spiral lockseam or welded with gauges, reinforcement, and supports conforming to SMACNA Duct Construction Standards Metal and Flexible: Positive pressure applications only, up to 10" w.g. For negative pressure applications, submit special design and reinforcements required.

2.03 DAMPERS

A. Fire Dampers:

1. Fire Dampers shall be installed at locations shown on the drawings and shall meet the requirements of NFPA 90A. Dampers shall be constructed, tested and stamped in accordance with UL555 consistent with the fire rating of the partition in which they are installed.

2. Dampers shall be classified for "Dynamic Closure" to shutoff against airflow for a minimum of 2375 FPM and 4" w.g. for horizontal or vertical flow. Each damper shall bear a UL stamp be marked with the UL hour classification, flow direction, and maximum pressure and velocity and "for use in dynamic systems".

3. The dampers shall be curtain type and the fire damper's blades shall be retained in a recess such that the free area of connecting ductwork is not reduced.

4. Fire dampers shall be rated for a minimum of 1 1/2 hours and have a fusible link rated 50 °F above the maximum temperature of the system, but not less than 160 °F.

5. Provide a hook on the fusible link, so that link can be easily removed to check damper for operation.

6. Each damper shall be shipped with the manufactures UL installation instructions and the dampers shall be installed in accordance with these instructions.

B. Combination Fire/Smoke Dampers:

1. Combination Fire/Smoke Dampers shall be installed at locations shown on the drawings and shall meet the requirements of NFPA 90A. Dampers shall be constructed, tested and stamped in accordance with UL555 and UL555S consistent with the fire rating of the partition in which they are installed.
2. Dampers shall be classified for "Dynamic Closure" to shutoff against airflow for a minimum of 2375 FPM and 4" w.g. for horizontal or vertical flow. Each damper shall bear a UL stamp be marked with the UL hour classification, flow direction, and maximum pressure and velocity and "for use in dynamic systems".
3. Dampers shall be supplied with a factory-mounted actuator. Single piece airfoil damper blades for rectangular dampers. Leakage Class I and temperature rated to withstand temperatures to 450^{o}F.
4. Fire dampers shall be rated for a minimum of 1 1/2 hours and have a fusible link rated 50 °F above the maximum temperature of the system, but not less than 160 °F.
5. Provide a hook on the fusible link, so that link can be easily removed to check damper for operation.
6. Each damper shall be shipped with the manufactures UL installation instructions and the dampers shall be installed in accordance with these instructions.

C. Outside Air Dampers: Dampers shall be low-leakage, airfoil, type; 6063 T5 heavy gage aluminum blades and frame; extruded vinyl seals. Manufactured by Ruskin; model CD-50.

D. Manual Balancing Dampers (Supply Air and General Exhaust Systems):

Dampers may be factory or contractor fabricated per SMACNA Duct Construction Standards Metal and Flexible section for Volume Dampers with the following exceptions:

1. Dampers shall be prefabricated in a frame to attach to the duct. The frame for rectangular dampers shall be minimum 16 gauge galvanized steel structural hat channel with reinforced corners.
2. Bearings shall be sleeve type synthetic or oil impregnated bronze, pressed into the frame.
3. Dampers shall have an external locking manual quadrant. On duct systems with external insulation, the quadrant shall be installed with a standoff bracket to clear the insulation. The quadrant shall have a wing nut for locking the

damper in place and a scale for indicating the position of the damper. (A handle attached directly to the damper shaft is not acceptable)

4. The end of the shaft shall be permanently marked to indicate blade position.
5. Dampers shall be of the same material as the duct material.
6. Blades shall be positively locked to the shafts.
7. Round dampers up to 24" shall be single blade butterfly type. Frames shall include rolled stiffener beads to allow easy sealing of spiral ductwork joints.

E. Manual Balancing Dampers (Lab Exhaust Systems):

Dampers shall be factory fabricated either butterfly or blast gate type and rated for up to 3000 FPM velocity and 4" w.g. For pressures greater than negative 4" w.g., dampers shall be constructed per SMACNA Round Industrial Duct Construction Standards.

1. Bearings shall be sleeve type synthetic or oil impregnated bronze, pressed into the frame.
2. All butterfly dampers shall have an external locking manual quadrant. On duct systems with external insulation, the quadrant shall be installed with a standoff bracket to clear the insulation. The quadrant shall have a wing nut for locking the damper in place and a scale for indicating the position of the damper. (A handle attached directly to the damper shaft is not acceptable)
3. Blast gate dampers shall have a bolt to lock the blade in position.
4. The end of the shaft shall be permanently marked to indicate blade position.
5. Dampers shall be of the same material as the duct material.
6. Continuous through shafts of ½" diameter and welded or bolted to the blades.

F. Control Dampers: Control dampers shall be furnished under section 13493 – HVAC Controls and Energy Management System and as listed on the drawings.

2.04 HANGERS AND SUPPORTS

A. General: Refer to SMACNA Duct Construction Standards - Metal and Flexible, Rectangular Industrial Duct Construction Standards, and Round Industrial Duct Construction Standards respectively for rectangular and round ductwork for installation of hangers and spacing.

1. Straps and angles shall be manufactured from galvanized steel; rods shall be manufactured from uncoated or galvanized steel.
2. Perforated iron band for duct support is prohibited.
3. Wire for duct support is prohibited.

B. Building Attachments: Shall be concrete inserts, powder actuated fasteners or structural steel fasteners compatible with building materials. Do not use powder-

actuated fasteners for concrete slabs less than 4 inches thick. Screwed fasteners shall be load rated.

C. Exterior Ducts: Unless detailed otherwise on the drawings, exterior ducts supported on roofs shall be supported with structural steel angle or channel sized per SMACNA standards for trapeze hangers and supported with pipe or angle columns.

1. Hangers shall be spaced a minimum of 5' on center.
2. The minimum size of the trapeze hanger shall be 1-1/2" x 1-1/2"x 3/16" angle or 3 X 4.1 lbs. Channel
3. Minimum column supports shall be 2" diameter standard weight pipe and coordinated with roofing penetration requirements.

2.05 SEALANTS

A. Self-adhering vinyl coated fabric duct tape is not permitted, except to temporarily seal the duct openings for contamination prevention.

B. Outdoor Ducts (without exterior insulation):

1. Polymeric rubber, resins, and reinforcing materials dispersed in solvent: 24 hour cure time, UV resistant, operational temperature range of -20 to +150 °F, manufactured by United McGill, type Uni-Weather or approved equal.

C. Indoor Ducts and Outdoor Ducts with Exterior Insulation:

1. Ductwork: Water based, vinyl acrylic polymeric sealant; nonflammable; fire retardant; operational temperature range of -25 to 200 °F, 48 hour cure time. Manufactured by Ductmate, type Pro-Seal or approved equal.
2. Pressurized Ductwork: Ductwork that is to be sealed while under pressure shall be sealed with water based mastics with fiberglass reinforcing and with short curing times. Manufactured by Versa Grip, type 102 (Hard Cast) or approved equal.

D. Fire Stopping: Seal ductwork penetrations to halt the spread of fire, water and smoke through firewalls and floors and as indicated on contract drawings with fire resistant sealant. Maximum allowable flame spread, as tested by ASTM E814, is 25 with a smoke-developed rating no higher than 50. Fire stopping materials shall be in accordance with Section 07270, "Firestop and Smokestop Systems":

2.06 ACCESS DOORS

A. Duct Access Door shall be factory fabricated, galvanized steel, double skin, and insulated. Door shall conform to SMACNA HVAC Duct Construction Standards and shall be hinged with sash locks and gaskets. Access doors shall be provided adjacent to each fire damper, smoke damper, smoke detector, and control device and for any additional locations shown on the drawings. The opening size shall be large enough to permit maintenance and resetting of the device.

B. Plenum Access Door shall be double wall constructed per SMACNA Duct Construction Standards Metal and Flexible for casing Access Doors – 3-10" W.G. Doors shall 20 inches wide unless shown otherwise on the drawings and doors shall open against the air pressure.

2.07 LOUVERS

A. Construction: Louvers shall have the maximum free area (minimum 50% of nominal size) and minimum pressure drop for each type as listed on the drawing louver schedule and shall be manufactured from 6063-T6 aluminum, or 18 gage galvanized steel and finished with Kynar. Slats shall be inclined at least 45 degrees from the horizontal and overlap a minimum of 1 inch Slats over 48 inches shall have intermediate supports. An integral rain channel shall be formed with the slats. Louvers shall include a ½-3/4 inch mesh galvanized steel or aluminum bird screen. Louvers shall be compatible with the adjacent substrate.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Construct and install ducts to SMACNA HVAC Duct Construction Standards Metal and Flexible, SMACNA Round Industrial Duct Construction Standards, or SMACNA Rectangular Industrial Duct Construction Standards (as per Part 2 "Products") and this specification.

B. Ductwork installation shall not proceed, until representatives from the other contracting trades have been consulted to ensure that there are no layout or installation conflicts, unless otherwise directed by the SDR.

C. Structural conditions of the building may indicate that modifications to the ductwork are necessary. Dimensions on drawings indicate free inside area. Actual duct dimensions may need to be altered for insulation allowance when required. Ducts shall be transitioned or divided as may be required; whenever this is necessary, the equivalent area shall be maintained. Such corrections shall be approved and directed by the SDR, before modifications are started.

D. Exit passageways, stairs, ramps and other exits shall not be used as a part of the air return, supply or exhaust.

E. Installation and workmanship shall be such that the system is free from buckling, warping, breathing (oil canning), and vibration. Installation must conform to the requirements set forth in NFPA 90A and 90B.

3.02 PREPARATION

A. Open ends of ducts shall be covered and sealed with duct tape during installation to prevent debris from contaminating system.

3.03 INSTALLATION

A. Flexible Ducts:

1. Provide flexible duct in fully extended condition, free from kinks.
2. Use only the minimum length required to make the connection.
3. Do not exceed 5'-0" in length, fully extended.
4. Where horizontal support is required, hanger or saddle material shall be wide enough so that it does not reduce the internal diameter of the duct and shall be a minimum 1" wide banding material hangers at not more than 2'-6" centers. Maximum allowable sag ½" per foot of support spacing. Flexible duct shall extend straight for several inches from a connection before bending.
5. Make joints and connections with 1/2" wide positive locking steel, nylon or plenum rated straps. Connections shall be per SMACNA Duct Construction Standards.
6. Use insulated flex where insulated duct is required.

B. Metal Ductwork:

1. Install with a minimum of 4" separation from earth to the duct or insulation finish.
2. Securely fasten at each change in direction.
3. Install branch connections and couplings tight to the duct wall surface with a minimum of projection into duct. Secure with sheet metal screws at intervals of 12 inches with a minimum of 3 screws in each connection.

C. Underground Ducts: Use PVC coated galvanized steel for underground ducts and install in accordance with the manufacture's requirements. Repair damage to PVC coatings with manufacture's recommended materials.

1. Duct in concrete slabs shall be round and encased in at least 2" of concrete.
2. Use a vibrator to fill voids in concrete

D. Insulation: Shall be installed as detailed in Section 15081, "Duct Insulation." The insulation, facings, tapes and adhesives applied to the exterior surfaces of ducts located within the buildings shall have a composite flame spread of 25 or less and a smoke developed rating of 50 or less.

E. Sealing Ductwork:

1. 0"-2" w.g. classification: Transverse joints shall be sealed as per SMACNA guidelines for Seal Class C using products listed in Section 2.
2. Greater than 2" w.g. positive or ½" negative classification: Joints, seams and penetrations shall be sealed as per SMACNA guidelines for Seal Class A. The shop procedure for sealing ducts shall be equivalent to the following: before fittings and joints are assembled, duct adhesive shall be applied, using a pump-

type oil can, to rivets, grooved seams, and tap-off collars on the internal side of the metal. Pittsburgh lock pocket shall be flooded with adhesive, using pump-type oil can, and the duct assembled. Duct sealer shall be brushed around reinforcing corners, rivets, notches and tap-off collars after duct is assembled. Where joints are not accessible for proper sealing, hand holes should be cut in the duct and joints sealed from the inside. Fabricate hand hole covers and cover the holes with insulation. Special care shall be taken to seal all duct corners.

3. Stainless steel exhaust ductwork: Joints to be continuously welded.

3.04 GAS FIRED EQUIPMENT

A. Combustion air and venting of gas-fired equipment shall conform to the requirements of the International Mechanical Code.

3.05 DUCT LINERS

A. Install duct liners at locations as shown on the drawings and in accordance with NAIMA Fibrous Glass Duct Liner Standard. Apply with a single layer of indicated thickness.

B. Do not install liners within 24" of evaporative cooling equipment, across fire dampers, or within 3' down stream of duct humidifiers.

C. Apply adhesive coating to all exposed edges of liner that do not receive nosing treatment.

D. Metal nosing shall be installed over exposed liner edges that face upstream of the airflow.

3.06 HANGERS AND SUPPORTS

A. Metal strapping for supporting and hanging ductwork and VAV boxes may be attached to metal roof decks with the following conditions;

1. The metal roof deck is 22 gauge or heavier.
2. For round ductwork 18 inch diameter or less and rectangular ductwork having a perimeter of 96 inches or less and duct thickness of 20 gauge or lighter.
3. Metal strapping must be attached to the side flute of the metal deck with one each No. 10 Buildex screw (or other equal load rated fastener) at each end for U-shaped straps and two each No. 10 screws for single point attachments.
4. VAV boxes weighing 110 lbs. or less. VAV boxes shall be supported separately from ductwork and piping.

B. Hangers shall be installed plumb and shall present a neat appearance.

C. Strap hangers shall extend the full depth of the duct, bend and extend 1 inches under and against the bottom of the duct.

D. Attach hangers to the ducts using rivets or screws of appropriate sizes 6 inches on center (minimum of 2 each side) and on the bottom return.

E. All ducts shall be rigidly supported.

1. Where vertical ducts pass through floors or roofs, supporting angles shall be attached to ducts and to the structure.

2. Place supporting angles on at least two sides of the duct.

F. Reference Section 2 for Hangers and Supports construction and spacing data.

3.07 CONNECTORS

A. Provide flexible connections, not less than 4 inches wide, constructed of approved fireproof, waterproof, non-asbestos, glass fabric, at the inlet and outlet connection of each fan unit, securely fastened to the unit and to the ductwork by a galvanized iron band provided with tightening screws. There shall be no metal-to-metal contact at flexible connections. There shall be no stretching of the flexible material at flexible connections. This connection shall be UL listed, to meet NFPA 90 requirements and the following applications;

1. Indoor Supply/Return Air: Neoprene coated glass fabric, minimum 30 oz./sq.yd., Ventfabrics - “Ventglas” or DuroDyne - “Neoprene”.

2. Outdoor Supply/Return Air: U.V. resistant Hypalon coated glass fabric, minimum 24 oz./sq.yd. Ventfabrics – “Ventlon” or DuroDyne – “Durolon”.

3. Laboratory/Chemical Exhaust: Teflon coated glass fabric, minimum 16 oz./sq.yd., Ventfabrics – “Ventlel”.

3.08 DAMPERS

A. Fire and Smoke Dampers:

1. Dampers shall be installed in a sheet-metal collar which shall be reinforced with angle-iron frames. Dampers shall be installed according to SMACNA Fire, Smoke and Radiation Damper Installation for HVAC Systems and the manufactures requirements.

2. Provide access doors at all fire damper locations. Access doors shall be located so that the spring catch is accessible when the damper is closed.

3. Fire dampers shall be supported independent of ductwork in the ceiling, wall or floor, as conditions at the site dictate.

4. Fire dampers shall not be installed in exhaust systems.

5. Duct Connectors: Ducts shall be connected to fire and smoke dampers with slip joints so that the damper will remain within the fire barrier, even if the duct should collapse.

B. Balancing Dampers: Shall be installed where shown on drawings and as may be required to balance system.

C. Control Dampers: Control dampers shall be furnished under section 13493 – Facilities Control System and as listed on the drawings.

3.09 ACCESS DOORS

A. Duct Access Doors: Provide in locations indicated on drawings and as required to properly and easily service, maintain, and inspect duct coils, fire dampers and other equipment.

B. Plenum Access Doors:

1. Doors shall be provided with a flat iron or angle iron stiffening frame and so constructed that they can be operated without twisting or distorting.
2. The opening at each door shall be provided with a continuous reinforcing galvanized bar or angle against which the door will close, and be provided with a sponge rubber gasket to make the door opening airtight.
3. Walk through type doors at plenum chambers shall meet the requirements of SMACNA HVAC Duct Construction Standards – Metal and Flexible

3.10 PLENUMS

A. Panels shall be assembled by interlocking the flanged end with the double standing seam and bolting on 18" centers. Seams shall project into the airside of the apparatus casings. Sealer shall be poured into, or plenum tape wrapped around the double seam prior to assembly. Joint shall be assembled immediately after sealer is applied. Paint outside of seam with sealer and allow 24 hours to dry before applying air pressure.

B. Panels shall be braced rigidly in place by 1-1/2" x 1-1/2" x 1/8" angles spaced on 4'-0" centers maximum and run continuous for the full length or width of the casings.

C. Casings shall be secured to concrete curbs on floors, or walls by a 2" x 2" x 3/16" toe angle, gasketed between the casing and the toe angle and gasketed or grouted between the toe angle and the floor. The toe angles shall be secured to the floor or wall by 1/4" bolts 1' -0" o.c., shot into the floor or the wall or 1/4" "J" bolts set in concrete 1'-0" o.c., through the flange angles of the panels. The toe angles shall run continuously for the full length of the casing in contact with the floor or wall. Seal joints airtight with sealer.

D. Rivets and bolts through the casing shall be gasketed.

E. Casings shall be constructed according to SMACNA HVAC Duct Construction Standards - Metal and Flexible.

3.11 DUCT PENETRATIONS

A. Ducts through masonry openings and along edges of all plenums at floors and walls, shall be provided with a continuous 2" x 2" x 1/8" galvanized angle iron which shall be bolted to the construction and made airtight to the same by applying silicone caulking compound. Sheet metal at these locations shall be bolted to the angle irons.

B. Ducts through drywall or plaster walls and ceilings shall be finished with a 22 gage galvanized steel flange neatly installed.

3.12 LOUVERS

A. Install storm louvers at air openings in the outside walls where indicated on the drawings. The exterior face of the louver shall have a flange all around, neatly fitted to the building wall, flashed at top and all sides caulked. On the outside face of each louver, install a removable screen, consisting of 1/2" mesh, galvanized wire screen in a galvanized channel frame.

3.13 FILTERS AND GAUGES

A. Filters: Furnish and install filters as scheduled on the drawings. Follow manufacturer's directions for installing each type of filter. The filters shall be installed such that there will be no leakage around the filter banks. Filters in frame holders shall be provided with lift handles. Hinged access panels or doors shall be installed for convenient access to each filter section. Filter retainer frames shall be arranged to provide proper support to facilitate each filter fitting tightly in place with provision to seal properly. Provide reinforcement as required such that there is no more than two inches of deflection across the filter rack during operation. Clean filters shall be installed before Test and Balance is begun. Filters banks shall be located in a convenient and accessible place, so that it can be serviced without the use of a stepladder. If this is impractical, install a permanent ladder or scaffolding for ease of service.

B. Filter gauges: Furnish and install Magnehelic gauges for the measurement of airflow resistance through the filters at each bank of filters. Furnish each gauge with two 3-way ball valves for venting and gauge adjustment.

3.14 INSPECTION AND TESTING

A. The Contractor shall be responsible for providing a joint and cooperative effort to coordinate the test and balance as specified in Section 15901, “System Component Checkout and Balance.”

B. Inspection: The contractor shall ensure that filters, dampers, louvers, gauges, electrical components and other accessories referenced in this document are installed correctly and system is operating in compliance with requirements prior to start-up and request for final inspection.

C. Testing: Ductwork rated 4" w.g. and higher, laboratory exhaust ducts and ductwork indicated on the contract documents shall be tested for leaks. Testing is not required for other ductwork rated 0 to 3 " w.g.

1. Testing shall be done following guidelines in SMACNA-HVAC Duct Leakage Test Manual.

3.15 CLEANING

A. Ductwork shall be cleaned as it is being installed, to remove oil film and dust allowing sealants, such as silicone caulk, to cure before duct is cleaned and sealed.

END OF SECTION