CONSTRUCTION STANDARD SPECIFICATION

SECTION 16401

ELECTRICAL DISTRIBUTION SYSTEM, AERIAL

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PART 1 - GENERAL

1.01 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The latest edition of the standards listed below shall be used.

A. American National Standards Institute, Inc. (ANSI) Standards:

C2	National Electrical Safety Code.
C8.35	Specifications for Weather-Resistant Polyolefin-Covered Wire and Cable.
C29.1	Test Methods for Electrical Power Insulators
C29.2	Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type.
C29.3	Wet-Process Porcelain Insulators - Spool Type.
C29.4	Wet-Process Porcelain Insulators - Strain Type.
C29.5	Wet-Process Porcelain Insulators - Low and Medium Voltage Types.
C29.6	Wet-Process Porcelain Insulators - High-Voltage Pin Type.
C29.7	Wet-Process Porcelain Insulators - High-Voltage Line-Post Type.
C29.8	Wet-Process Porcelain Insulators - Apparatus, Cap and Pin Type.
C29.9	Wet-Process Porcelain Insulators - Apparatus, Post-Type.
C37.30	Definitions and Requirements for High-Voltage Air Switches, Insulators, and Bus Supports.

C57.12.20	Transformers - Overhead-Type Distribution Transformers, 500 kVA and Smaller: High-Voltage 34,500 Volts and Below; Low-Voltage, 7970/13,800Y Volts and Below.
C78.380	Electric Lamps - High-Intensity Discharge Lamps - Method of Designation.
C82.4	Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple Supply Type).
C119.4	Electric Connectors - Connectors for Use Between Aluminum-To-Aluminum or Aluminum-To-Copper Bare Overhead Conductors.
C135.1	Galvanized Steel Bolts and Nuts for Overhead Line Construction.
C135.14	Staples with Rolled or Slash Points for Overhead Line Construction.
C135.17	Galvanized Ferrous Bolt-Type Insulator Pins with Lead Threads for Overhead Line Construction.
C135.22	Galvanized Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction.
C135.30	Galvanized Ferrous Ground Rods for Overhead or Underground Line Construction.
C135.33	Galvanized Ferrous Crossarm Gains for Overhead Line Construction.
C136.2	Roadway Lighting - Luminaires - Voltage Classification.
C136.3	Roadway Lighting Equipment - Luminaire Attachments.
C136.6	Roadway Lighting Equipment - Metal Heads and Reflector Assemblies - Mechanical and Optical Interchangeability.
C136.9	Roadway Lighting Equipment - Socket Support Assemblies for Metal Heads - Mechanical Interchangeability.
C136.10	Roadway Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing.
C136.11	Roadway Lighting Equipment - Multiple Sockets.
C136.13	Roadway Lighting - Metal Brackets for Wood Poles.
C136.14	Roadway Lighting Equipment - Enclosed Side-Mounted Luminaires for Horizontal-Burning High-Intensity-Discharge Lamps.

C136.15	Roadway Lighting - High-Intensity-Discharge and Low-Pressure Sodium Lamps in Luminaires - Field Identification.
Z55.1	Gray Finishes for Industrial Apparatus and Equipment
05.1	Specifications and Dimensions for Wood Poles.

B. American Society for Testing and Materials (ASTM) Publications:

A123 REV A	Standard Specification for Zinc (Hot-Galvanized) Coatings on Iron and Steel Products.
A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
A475	Standard Specification for Zinc-Coated Steel Wire Strand.
A575	Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
A576 REV B	Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
B1	Standard Specification for Hard-Drawn Copper Wire.
B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
B117	Standard Test Method of Salt Spray (Fog) Testing.
B228	Standard Specification for Concentric-Lay-Stranded Copper-Clad Steel Conductors.
B230	Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes.
B231	Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors.
B232	Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR).
B398	Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes.
B399	Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors.
B416	Standard Specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors.
B498	Standard Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR).

D923	Standard Methods of Sampling Electrical Insulating Liquids.
D3304	Analysis of Environmental Materials for Polychlorinated Biphenyls.

C. American Wood-Preservers' Association (AWPA) Standards:

C4	Poles - Preservative Treatment by Pressure Processes.
C25	Sawn Crossarms - Preservative Treatment by Pressure Processes.
P1	Coal Tar Cresote for Land and Fresh Water Use.
P5	Waterborne Preservatives.
P8	Oil-Borne Preservatives.
P9	Solvents and Formulations for Organic Preservative Systems.

D. Illuminating Engineering Society (IES) Publication:

RP-8	Roadway Lighting.

E. Institute of Electrical and Electronics Engineers (IEEE) Standards:

No. 18	Standard for Shunt Power Capacitors.
No. 24	Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings.
No. 142	Recommended Practice for Grounding of Industrial and Commercial Power Systems.
No. 404	Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5000V Through 46,000V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500V Through 500,000V.

F. National Electrical Manufacturers Association (NEMA) Publications:

HV 2	Application Guide for Ceramic Suspension Insulators.
LA 1	Surge Arresters.
SG 2	High-Voltage Fuses.
WC 5 Rev. 1 thru 14	Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

WC 7	Cross-Linked-Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
WC 8	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

G. International Electrical Testing Association (NETA):

Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

H. National Fire Protection Association (NFPA) Publication:

70	National Electrical Code.

I. U.S. Department of Agriculture, Rural Electrification Administration (REA) Specifications:

DT-5B:PE-16	Wood Crossarms (Solid and Laminated) Transmission Timbers and Pole Keys.

J. Sandia National Laboratories Construction Standard Specifications:

Section 01330	Submittal Procedures
Section 02584	Underground Ducts and Utility Structures
Section 03300	Cast-In-Place Concrete
Section 16001	Electrical Work
Section 16124	Medium Voltage Cable
Section 16475	Primary Systems Safety

K. Underwriters' Laboratories, Inc. (UL) Publications:

Electrical Construction Materials Directory.

UL 467	Grounding and Bonding Equipment.
UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors.
UL 486B	Wire Connectors and Soldering Lugs for Use with Aluminum Conductors.
UL 1571	Incandescent Lighting Fixtures.
UL 1572	High Intensity Discharge Lighting Fixtures

1.02 SUBMITTALS

A. Proof of Compliance: Materials or equipment specified to conform to the standards or publications, and requirements of Federal Specification, ANSI, ASTM, AWPA, IEEE, IES, NEMA, NFPA, REA, or UL shall require the Contractor submit proof that the items furnished under this section of the specifications conform to such requirements. The label of, or listing in the Electrical Construction Materials Directory of UL or the manufacturer's certification or published catalog specification data statement that the items comply with applicable specifications, standards publications and with the manufacturer's standards will be acceptable evidence of such compliance.

B. List of Equipment and Materials: A complete itemized listing of equipment and materials proposed for incorporation into the work shall be submitted. Each such itemization shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item. If wood crossarms and poles are specified, the species of wood shall be listed with the type of treatment used to preserve the wood.

C. Instruction Manuals: Instruction manuals for the system(s) and equipment furnished shall be in accordance with the requirements of this section. Three copies of instruction manuals shall be furnished within 7 calendar days following the completion of factory tests and shall include assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked and all documents previously submitted and approved. Manuals shall also include data outlining step-by-step procedures for system startup and operation, and a troubleshooting guide that lists possible operational problems and corrective action to be taken. A brief description of all equipment and their basic operating features shall also be included. Documents shall be bound in a suitable binder adequately marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent equipment information and content of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers. Three additional copies of the instruction manuals shall be submitted within 30 calendar days following the approval of the manuals.

D. Manufacturer's Certifications

1. Certificates of Compliance: Certificates shall be prepared by the manufacturer when the manufacturer's published data or drawings do not indicate conformance with other requirements of these specifications.

2. Certified Factory Test Reports: Certified factory test reports shall be submitted when manufacturer performs routine factory tests normally performed by the manufacturer, including tests required by standards listed in Section 1.01: REFERENCES. Additional certification is required to verify each transformer has passed a production line impulse test consisting of one reduced-wave and one full-wave lightning impulse test on each fully-insulated high-voltage terminal.

E. Contractor's Data: The Contractor shall submit the following types of data to supplement the Contractor's drawings.

1. Certifications: Certifications shall be submitted when specified or required, including Certification of the Qualifications of Medium-Voltage Cable Installers, Certified Factory and Field Test Reports, and Certificates of Compliance submitted in lieu of other proofs of compliance with these contract provisions.

2. Certified Field Test Reports: Field test reports shall be written and certified by the Contractor to the Contracting Officer. Field tests shall include cable, operational, and resistance-to-ground tests.

F. Contractor's Drawings: The Contractor shall submit drawings as required to supplement contract drawings, manufacturer's data and drawings, and Contractor's data to demonstrate compliance with applicable contract requirements. Drawings shall be dimensioned or scaled to show the relative arrangement and mounting details of the equipment or equipment assemblies.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Service Conditions: Items furnished under this section shall be specifically suitable for the following service conditions:

1. Altitude: 5500 ft.

2. Wind Loading @ 80 mph.

B. Standard Product: Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 5 years.

C. Nameplates

1. Each major component of equipment shall have as a minimum the manufacturer's name, address, and catalog or style number on a nameplate securely attached to the item of equipment. In the case of wood poles & crossarms, species of wood, type of preservative treatment, year manufactured, class, and length shall be identified. Nameplates for individual items of electrical equipment shall be as specified in referenced publications and shall be provided on each item of equipment.

2. Nameplates shall be made of corrosion-resisting metal with not less than 1/4-inch tall raised or engraved characters. The nameplate shall be mounted on the front of the enclosure or on the butt of the pole. Branding of nameplate information is allowed in lieu of metal nameplates on wood poles and crossarms. Steel poles shall have labels approximately 3 to 4 feet above grade.

3. Transformer nameplates shall be permanently marked with a statement to the effect that the transformer dielectric to be supplied is non-polychlorinated

biphenyl classified with less than 1 parts per million (ppm) polychlorinated biphenyl (PCB) content.

D. Prevention of Corrosion

1. Metallic materials shall be protected against corrosion as specified. Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486B shall be used.

2. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A123 and A153.

3. Luminaires fabricated from ferrous metals, unless hot-dip galvanized or of porcelain enamel finish, shall be factory finished with a weather-resistant finish that will withstand 200 hours exposure to the salt spray test specified in ASTM B117. Finish color may be the manufacturer's standard, unless otherwise indicated.

2.02 AUTOMATIC CIRCUIT RECLOSERS

A. Automatic circuit reclosers shall be outdoor vacuum type, complete with devices, attachments, and accessories required for installation and operation; and shall be suitable for mounting on a single pole. Each recloser shall have continuous current, minimum tripping current, interrupting current, and making current ratings and reclosure times as indicated and shall be rated for the voltage and phase of the system in which it is installed. Three-phase lockout shall be provided on three-phase circuits. Hydraulically-controlled reclosers shall be provided with tank drains and sampling valves. Surge arrester protection shall be provided.

B. Reclosers shall include provisions for a sequence of not less than three automatic reclosing operations unless otherwise noted, followed by lockout if the circuit fault persists, and for manual opening, closing, and lockout by use of a hookstick. Operating sequence shall be adjustable for 1, 2, 3 and 4 operations to lockout and for combinations of instantaneous operations followed by time delay openings to secure coordination with other reclosers and fuses in the medium-voltage distribution system. Reclosers shall automatically reset within a definite time interval after a successful reclosure and shall be supplied with devices needed to provide the necessary operating power.

2.03 CAPACITORS

A. Capacitors shall conform to IEEE No. 18.

B. Capacitor equipment shall be of the three phase, grounded-wye, outdoor type rated for continuous operation. Equipment shall be suitable for mounting on a single pole. Polychlorinated biphenyl (PCB) shall not be used as the dielectric. Equipment shall be adequately rated for the system voltage. The indicated kvars shall be non-switched.

2.04 CONDUCTORS

A. Bare Conductors: Bare Conductors shall meet the following requirements:

1. Aluminum-Composition Conductors

   a. All-aluminum conductors, (1350-H19), ACC; ASTM B230.

   b. All-aluminum-alloy conductors, (6201-T81) AAAC; ASTM B399. The alloy shall be 6201 according to ASTM B398.

   c. Aluminum-conductor-steel-reinforced, ACSR; ASTM B232.

   d. Zinc-coated (galvanized) steel-core conductors, ASTM B498.

2. Copper Conductors: ASTM B1 and B8 as appropriate to the conductor size, hard-drawn temper.

3. Conductor types shall not be mixed on any project, unless specifically permitted. Conductors larger than 2 AWG shall be stranded. Minimum conductor size shall be 6 AWG CU or conductors of equivalent strength. See Table I "Overhead Conductor Loading" for loading ratings.

B. Insulated Conductors

1. Messenger-supported medium-voltage cables shall be of the preassembled three-conductor type conforming to the construction requirements of NEMA WC8, having a rated circuit voltage as indicated, a 133 percent insulation level, and a Type III cable construction. Conductors shall be annealed copper or 1350 alloy aluminum. Insulation shall be either cross-linked thermosetting-polyethylene conforming to NEMA WC7 or ethylene-propylene-rubber conforming to NEMA WC8.

2. Messengers may be zinc-coated steel, aluminum-clad-steel, copper-clad-steel, or composite-copper and copper-clad steel.

3. Low-Voltage Cables: Neutral-supported secondary and service drop cables shall be insulated copper with bare hard-drawn-copper or copper-clad steel neutrals or insulated aluminum with bare 1350 alloy aluminum or ACSR neutrals. The cables shall conform to the requirements of NEMA WC5 for thermoplastic insulation and NEMA WC7 for cross-linked-thermosetting-polyethylene insulation.

2.05 CONNECTORS AND SPLICES

A. Connectors and splices shall be of copper alloys for copper conductors, shall be of aluminum alloys for aluminum-composition conductors, and shall be of a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors.

B. Bare conductor connectors and splices of aluminum-composition and aluminum-composition to copper shall meet ANSI C119.4 requirements.

C. Insulated aerial low-voltage cable connectors and splices shall meet the requirements of UL 486B for aluminum composition and aluminum-composition to copper terminators; and the requirements of UL 486A for copper to copper terminators.

D. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors.

2.06 CROSSARM ASSEMBLIES

A. Crossarms shall meet the requirements of REA Spec. No. DT-5B:PE-16 solid wood, distribution type, except cross-sectional area with pressure treatment conforming to AWPA C25, and a 1/4 inch, 45° chamfer on all top edges. Cross-sectional area minimum dimensions shall be as indicated on the drawings.

B Crossarm gains shall meet ANSI C135.33 requirements.

C. Crossarms shall be 8 feet in length, unless specified otherwise on the construction drawings. Crossarms shall be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 1/10-inch per foot of length. Bend or twist shall be in one direction only. Crossarms shall have a stamp or nameplate indicating manufacturer, year of manufacture, species of wood, and type of treatment, and grade (close grain or dense).

2.07 FUSES AND FUSE CUTOUTS

A. Medium-voltage fuses shall meet NEMA SG2 requirements.

B. Primary fuse cutouts shall meet NEMA SG2 requirements.

C. Primary-fuse cutouts shall be of the 200A non-loadbreak open type construction and of the heavy-duty type ratings and type indicated. Open-link cut-outs are not acceptable. Fuses shall be the dropout type. Fuse cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.08 GROUNDING AND BONDING

A. Equipment for grounding and bonding shall meet UL 467 requirements.

B. Wire for grounding and bonding shall be softdrawn copper that meets ASTM B8 requirements.

2.09 GANG-OPERATED LOAD INTERRUPTER SWITCHES

A. Load interrupter switches shall meet ANSI C37.30 standards.

B. Gang-operated load interrupter switches shall be of the outdoor, manually operated, three-pole, single-throw type with either tilting or rotating insulators and equipped with interrupters capable of load break and load make equal to switch's continuous current rating. Each switch shall be suitably preassembled for the indicated configuration and mounting. Moving contacts shall be of the high-pressure, limited area type, designed to ensure continuous satisfactory contact. Switches shall be fused or non-fused as indicated. Each switch shall have a continuous current rating as shown, a momentary asymmetrical current rating as shown, and shall be rated for the voltage of the system in which it is installed.

C. Switches shall be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground.

2.10 GUY ASSEMBLIES

A. Guy strand shall be 7 strand. Guy material shall be Class A zinc-coated-steel high-strength meeting ASTM A475 requirements, with a minimum breaking strength not less than 10,000 pounds or as shown, except where two or more guys are used to provide the required strength. Anchor rods shall be not be less than 8 feet in length by 3/4 inch in diameter or as specified on drawings.

B. Guy assemblies, including insulators and attachments, shall provide a strength exceeding the required guy strength. Thimbles or thimble-eyes shall be provided on anchor rods. A half-round yellow polyvinyl, fiberglass, or other suitable plastic guy marker, not less than 8 feet in length, shall be provided where shown or required at the anchor end of each guy, securely clamped to the guy or anchor at the bottom and top of the marker.

C. Holding capacities for down guys shall be based on a lead angle of 45 degrees as indicated. When field conditions prevent indicated lead angles, anchors shall be placed in other locations as approved by Sandia Delegated Representative (SDR).

2.11 INSULATORS

A. Insulators shall meet the general requirements of NEMA HV2.

B. Line Insulators

1. Low-voltage line insulators shall meet ANSI C29.2 and C29.3 standards.

2. Medium-voltage line insulators shall meet ANSI C29.2, C29.5, C29.6, and C29.7 standards.

C. Fiberglass strain insulators for guy wires shall meet ANSI C29.4 standards.

D. Apparatus insulators shall meet ANSI C29.8 and C29.9 standards.

E. Insulator tests shall meet ANSI C29.1 standards.

2.12 LAMPS AND BALLASTS, HIGH-INTENSITY-DISCHARGE TYPE

A. Lamps

1. Lamps shall be suitable for the burning position utilized.

2. High-pressure sodium and metal halide lamps shall meet ANSI C78.380 requirements for designations. Metal halide lamps shall be of the phosphor-coated type.

B. Ballasts

1. Ballasts shall conform to ANSI C82.4.

2. Ballasts shall be coordinated to the lamp the ballast supplies.

3. Ballasts shall be rated for the voltage indicated; and shall have a power factor of not less than 90 percent, a crest factor of 2.0 or less, and a voltage range of not less than plus or minus 10 percent.

4. Ballasts shall be suitable for operating at minus 22°F.

2.13 LUMINAIRES; ROADWAY AND SECURITY LIGHTING

A. Components shall meet the following requirements:

1. Attachments, ANSI C136.3.

2. Classification, ANSI C136.2.

3. Field identification marking, ANSI C136.15.

4. Interchangeability, ANSI C136.6 for metal heads and reflectors, ANSI C136.9 for sockets.

5. Luminaires, side-mounted, ANSI C136.14.

6. Sockets, ANSI C136.11.

7. Metal Brackets, ANSI C136.13.

8. Photo-Control Devices, ANSI C136.10.

B. Floodlighting luminaires shall meet the UL 1571 or UL 1572 requirements.

2.14 WOOD POLES

A. Wood poles shall have pole markings located approximately 10 feet from pole butts. Other locations standard with the pole manufacturer will be acceptable. Poles shall be machine trimmed by turning smooth full length, and shall be roofed, gained, and bored prior to pressure treatment. No climbing rungs shall be provided.

B. Wood poles shall meet ANSI 05.1 standards, completely pressure treated in accordance with AWPA C4. Waterborne preservatives shall conform to AWPA P5. Waterborne preservatives shall be either chromated or ammoniacal copper arsenate. Species listed in ANSI 05.1 for which a preservative treatment is not specified in AWPA C4 shall not be used, except that northern white cedar, if treated as specified for western red cedar, and western fir if treated as specified for Douglas fir, may be used.

C. Poles exhibiting any of the following defects will not be accepted: cross-breaks (horizontal cracks), catface (scars), compound through checks, decay, double sweep (poles having sweep in two planes), hollow butts or tops, improper framing, plugged holes (other than increment core holes), spike knots or any knot with bark inclusion, and split top.

D. Checks

1. Checks (vertical cracks) are permitted in the top of pole except for any check more than 1/8 inch wide and extending down from the top of the pole more than 12 inches and within 30 angular degrees from the axis of the face of pole directly above ground; and any through checks or splits.

2. Through checks or splits in the butt surface of the pole are permitted provided they do not extend upward along the pole more than 2 feet.

3. A check is considered to be continuous if it is not separated by at least 1/2 inch of wood. The maximum allowable width and length of any single check are found in Table II "Maximum Allowable Check Dimensions".

E. Knots

1. The diameter of any single knot or sum of the diameters of all knots in any one foot section shall not exceed the limits of Table III "Maximum Allowable Knot Dimensions". Knots 1/2 inch or less in diameter shall be ignored in applying the limitations for the sum of diameters.

2. The maximum single knot in any "sworl" shall be 2 inches in diameter. Maximum sum of knots in any "sworl" shall not exceed 20% of the pole circumference at the point of the sworl or more than allowed in Table III.

2.15 STEEL POLES

A. Steel poles shall provide adequate strength for the indicated loading conditions. Poles shall have tapered tubular members, either round in cross-section or polygonal. Pole shafts shall be one piece. Poles shall be welded construction; no bolts, rivets, or other means of fastenings are permitted, except as specifically indicated or approved. Attachment requirements shall be provided as indicated, including grounding provisions. Bases shall be of the anchor-bolt-mounted type unless direct bury is specified. Poles shall be hot-dip galvanized in accordance with ASTM A123 and shall not be painted. Climbing facilities will not be provided.

B. Pole markings shall be approximately 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and ft.-kips.

2.16 POLE LINE HARDWARE

A. Zinc-coated hardware material shall meet ANSI C135.1, C135.14, C135.17, C135.22, and C135.33 requirements.

B. Steel hardware material shall meet ASTM A575 and A576 requirements.

C. All hardware shall be hot-dip galvanized in accordance with ASTM A153.

2.17 SURGE ARRESTERS

A. Surge arresters shall be provided for protection of aerial-to-underground transitions, automatic circuit reclosers, capacitors, gang-operated load-interrupter switches, transformers and other indicated equipment.

B. Arresters shall be distribution-value class rated. Riser-pole class surge arrestors shall be used at transitions from overhead to underground distribution.

C. Surge arrestors shall meet NEMA LA1 requirements for the zinc-oxide type and shall be suitable for outdoor installations. Arresters for use at elevations in excess of 6,000 feet above mean sea level shall be specifically rated for that purpose. Arresters shall be equipped with mounting brackets suitable for the indicated installations.

2.18 TRANSFORMERS, OVERHEAD

A. Overhead transformers shall meet the ANSI C57.12.20 requirements for single phase, 60 Hz, 65°C temperature rise, mineral oil-filled conventional pole mounted transformer.

B. Transformer tanks shall be given a rust-inhibiting treatment and shall have a standard ANSI Color No. 70 gray finish. Transformer shall be provided with either a factory-applied corrosion-resistant finish that will withstand 200 hours exposure to the salt spray test specified in ASTM B117 or a stainless steel case. Self-protected transformers are not acceptable.

C. Transformer dielectric exceeding the 1 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be acceptable.

D. Padmounted transformers shall conform to the requirements of Section 16272, “Pad Mounted Transformers”.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Circuits installed in conduits or direct buried; and splices and terminations for medium-voltage cable, shall conform to the requirements of Section 02584, “Underground Ducts And Utility Structures”.

B. Secondary circuits installed in conduit on poles shall conform to the requirements of Section 16001, “Electrical Work”.

C. All work done on or near exposed energized circuits shall be done in conformance with the safety requirements of Section 16475, “Primary Systems Safety Requirements”.

D. The installation shall comply with the requirements and recommendations of NFPA 70 and ANSI C2 for medium loading districts, Grade B construction.

3.02 CONDUCTORS

A. General Installation Requirements

1. Conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Conductors shall be strung by the controlled tension method.

2. Proper care shall be taken in handling and stringing conductors to avoid abrasions, sharp bends, cuts, kinks, or any possibility of damage to insulation or conductors. Conductors shall be laid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall be at no time less than the applicable NEMA specification recommendation. When installed by machine power, conductors shall be drawn from a mounted reel through adequate stringing sheaves in approximately straight lines clear of obstructions. Vibration dampers shall be installed on all primary conductors including neutrals, having spans of 350 feet or longer.

3. Reel stands shall be heavily constructed and equipped with provisions for adequate braking to prevent slack in the conductor between the reels and the tensioning device. Proper alignment between the reel stands and the tensioning device shall be maintained to eliminate possible damage to the conductor.

4. Lead or pulling lines shall be of suitable strength and characteristics to properly perform the intended function; and shall be connected to the conductor with swivel connectors and stocking type grips.

5. In vertical risers on poles, cables shall be protected by conduit. The conduit shall be secured at intervals not exceeding 10 feet and within 12 inches of each side of any bend or termination.

6. Where lines pass through trees, trees shall be trimmed at least 8 feet clear on both sides horizontally and below for medium-voltage lines, and 4 feet clear on both sides horizontally and below for low voltage lines. No tree branches shall overhang horizontal clearances.

B. Messenger-Supported Cables

1. Medium-Voltage Cables: Medium-voltage cable messengers shall be attached to poles with clamps providing a strength exceeding the required messenger strength and with not less than 5/8-inch through-bolts. Messengers shall be

dead-ended, grounded, and guyed at corners and dead-ends, and at intervals not exceeding 1,000 feet along straight runs.

2. Low-Voltage Cables: Low-voltage cable neutrals shall be supported on clevis fittings using spool insulators. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 5/8-inch through-bolts. Open wire secondary with bare conductors on racks shall not be permitted. Drip loops shall be formed on conductors at entrances to buildings, cabinets, or conduits.

C. Conductor-To-Insulator Attachments: Conductors shall be properly attached to insulators using preformed ties. Tie-wire sizes shall be as indicated in Table IV "Tie Wire Requirements".

D. Armor Rods

1. Armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used.

2. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 200 feet, flat aluminum armor rods may be used. Flat armor rods, not less than 0.03 by 0.25 inch shall be used on No. 1 AWG AAC and AAAC and smaller conductors; and used on No. 5 AWG ACSR and small conductors. On larger sizes, flat armor rods shall be not less than 0.05 by 0.30 inches. For span lengths of 200 feet or more, pre-formed round armor rods shall be used.

3. The application of armor rods to the conductor shall be such that the center of the armor rods shall not deviate from the center of the conductor support by more than 2-1/2 inches.

4. Armor rods shall be installed where ruling spans are 300 feet or longer, or where indicated otherwise on construction drawings.

5. Pre-form tie wraps are acceptable in lieu of armor rods for attachment of conductors to the insulators.

3.03 CONNECTORS AND SPLICES

A. Splices and connectors shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type.

B. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable.

C. Inhibitors and compression tools shall be of types recommended by the connector manufacturer.

D. Primary line overhead transformer taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Hot-line clamps shall never be installed directly to aluminum (ACSR, AAAC) conductors.

E. Low-voltage connectors for insulated copper conductors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation.

F. Splices shall not be installed ten feet or less from a deadend crossarm.

G. No joints or splices shall be used at highway, railroad, or other public utility line crossings.

3.04 CONNECTIONS

A. Utility Connections: The Contractor shall coordinate the work with the Sandia Delegated Representative (SDR) and shall provide for final connections to the Sandia's electric lines.

B. Aerial Connections: Service-entrance conduits with termination fittings and conductors within the building shall conform to the requirements of Section 16001, "Electrical Work". Aerial services shall be attached to buildings approximately at the point indicated and shall be connected to the service entrance conductors. Supports at building shall be adequate to withstand required pulls, but in no case shall supports be rated less than 1,000 pounds.

C. Connections Between Medium-Voltage Aerial and Underground Systems: Where indicated, connections between medium-voltage aerial and underground systems shall be made as shown. Poles, brackets, crossarms, insulators, wire, surge arresters, primary-fuse cutouts, hardware, molding, grounding, and guying shall be provided under this section of the specifications and connected to the underground service. Conduit, cable, and cable terminations are specified in Section 02584, "Underground Ducts And Utility Structures".

3.05 CROSSARM ASSEMBLIES

A. Crossarms

1. Crossarms shall be bolted to poles with 5/8-inch through-bolts with square washer with locknut at each end. Bolts shall extend not less than 1/8 inch nor more than 2 inches beyond nuts.

2. On single crossarm construction, the bolt head shall be installed on the crossarm side of the pole. Single crossarms shall be placed on opposite sides of consecutive poles.

3. Double crossarms shall be securely held in position by means of 5/8-inch double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers with locknuts. Double crossarms shall be provided at ends of joint use or conflict sections, at dead-ends, and at angles and corners as indicated, to provide adequate vertical and longitudinal strength. Double crossarms shall be provide at each line-crossing structure, where lines not attached to the same pole cross each other, and elsewhere as shown.

4. Tangent Arms and Buck Arms: Tangent arms and buck arms shall be set at right angles to lines for straight runs and for angles 45° and greater. Tangent arms shall bisect angles of turns of less than 45°. Dead-end assemblies shall be used for turns where shown. Buckarms shall be installed, as shown, at corners and junction poles.

B. Braces

1. Wood braces shall be used for crossarm supports, unless specified otherwise on the construction drawings.

2. Flat braces (may be provided for 8 foot crossarms) shall be 1/4 inch by 1-1/4 inches, not less than 28 inches in length. Flat braces shall be bolted to arms with 3/8-inch carriage bolts with round or square washers with locknuts between boltheads and crossarms, and secured to poles with 1/2-inch by 4-inch lag screws after crossarms are leveled and aligned.

3. Angle iron braces (required for 10-foot crossarms) shall be 60-inch span by 18-inch drop formed in one piece from 1-1/2-inch by 1-1/2-inch by 3/16-inch angle. Angle iron braces shall be bolted to crossarms with 1/2-inch bolts with round or square washers with locknuts between boltheads and crossarms, and secured to poles with 5/8-inch through-bolts.

C. Equipment Arms: Equipment arms shall be set parallel or at right angles to lines as required to provide climbing space. Equipment arms shall be located below line construction to provide necessary wire and equipment clearances.

D. All bolted connections shall be torqued in accordance with Table V "NETA Bolt Torques for Bus Connections" unless the manufacturer specifies otherwise.

3.06 GROUNDING AND BONDING

A. General Requirements

1. Equipment, neutral, and surge arrester ground systems shall be installed at poles where indicated.

2. A ground resistance of not greater than 25 ohms shall be provided, unless otherwise specified. Ground resistances shall be measured in normally dry conditions not less than 48 hours after rainfall. Resistances of systems requiring separate ground rods shall be measured separately before bonding below grade. The combined ground resistance of separate systems bonded together below grade may be used to meet the specified ground resistance, but the minimum number of rods indicated must still be provided.

3. Ground Rods: Ground rods shall be of copper-clad steel, not less than 5/8 inch in diameter by 8 feet in length, and shall be driven into the ground until tops of rods are approximately 1 foot below finished grade. Where the specified ground resistance cannot be met with the indicated number of ground rods, additional ground rods, longer ground rods, or deep-driven sectional rods shall be installed and connected until the specified resistance is obtained, except that not more than three additional 8-foot ground rods shall be required at any one installation. Ground rods shall be spaced as evenly as possible at least 6 feet

apart and connected 2 feet below grade. The Contractor may, at his option, provide copper-coil-type grounds at wood poles in lieu of ground rods where the required ground resistance can be obtained by this method. The copper-coil-type ground shall consist of a coil of at least 12 feet of 6 AWG minimum bare copper wire stapled to the butt of the pole.

4. Connections: Connections above grade shall be made with bolted solderless connectors, and those below grade shall be made by a fusion-welding process. In lieu of a fusion-welding process, a compression ground grid connector of a type which uses a hydraulic compression tool to provide the correct circumferential pressure may be used. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire. Where ground wires are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be utilized.

B. Neutral Grounding

1. Neutral conductors shall be grounded at each pole. Ground wire sizes, not otherwise indicated, shall have a current-carrying capacity of at least 20 percent of the largest neutral conductor to which a ground wire is connected, but in no case smaller than 6 AWG. Where indicated on the drawings, the grounding conductor shall be connected to a 3/4 inch by 10 foot copperweld ground rod driven one foot below the top of the surface and approximately 3 feet out from the base of the pole. Bends greater than 45 degrees in ground wire connections to ground rods are not permitted.

2. The ground wire on wood poles shall be protected by half-round wood, plastic, or fiber molding extended for not less than 8 feet above the ground line. Rigid or intermediate steel conduit shall protect ground wires on poles from a point 14 inches above grade to a point 6 inches below grade. Conduits shall be terminated with a grounding bushing at each end, and the ground wire shall be connected to each bushing. Conduits shall be held in place by two, two-hole, galvanized, rigid conduit straps spaced approximately 9 inches apart. Moldings shall be stapled to wood poles at intervals not exceeding 2 feet, with one staple not more than 3 inches from each end of the molding. Single-point serrated staples of a type suitable for use with the molding shall be used for stapling molding to wood poles. When not covered by molding, ground wires shall be stapled to wood poles at intervals not exceeding 2 feet. Insulated ground wires are acceptable for use.

3. On metal poles, a preformed galvanized steel strap, 5/8-inch wide by 22-gage minimum by length as required, secured by a preformed locking method standard with the manufacturer, shall be used to support a ground wire installation on the pole and spaced at intervals not exceeding 5 feet with one band not more than 3 inches from each end of the vertical ground wire.

C. Equipment Grounding

1. Noncurrent-carrying metal parts of equipment and conductor assemblies, such as luminaires, medium-voltage cable terminations and messengers, metal poles, operating mechanisms of pole top switches, panel enclosures, transformers, capacitors, and recloser frames (cases) and other noncurrent-carrying metal

items shall be grounded as required. Ground wire sizes, not otherwise indicated, shall be not smaller than 6 AWG. Connections to earth shall be made in the same manner as required for secondary neutral grounding.

2. Equipment or devices energized at less than 750 volts may be connected to secondary neutral grounds of transformers with windings connected in open-delta or grounded-wye configurations.

3. Equipment energized at more than 750 volts shall be provided with grounds separate from secondary neutral grounds, but both grounds shall be bonded together below grade at the ground rods or to the ground counterpoise, as applicable.

4. Metal poles shall be grounded at each pole and these grounds shall not be interconnected with any other grounds.

D. Surge Arrester Grounding: Surge arresters shall be grounded. Ground resistance for distribution-class arresters shall be not more than 25 ohms. Ground wire connections shall be not less than 4 AWG for distribution arresters. Connections to earth shall be made in the same manner as for secondary neutral conductors and run to a ground rod separate from the secondary neutral ground rod. The aerial portion of surge arrester and secondary neutral grounds conductors shall be separate from and independent of each other but both grounds shall be bonded together below grade at the ground rods, or to the ground counterpoise, as applicable.

3.07 GANG-OPERATED LOAD INTERRUPTER SWITCHES

Operating handles shall be located approximately 3 feet 6 inches above finished grade, shall be insulated and grounded, and each handle shall be provided with a padlock arranged to lock the switch in both the open and the closed position. Insulation of switches shall include both insulated interphase rod sections and insulated vertical shafts.

3.08 GUY ASSEMBLIES

A. Guys shall be provided where shown, with loads and strengths as indicated, and elsewhere as required wherever conductor tensions are not balanced, as at angles, corners, and dead-ends. Guys shall be attached as near as practical to the center of the conductor load to be sustained. Where a single guy will not provide the required strength, two or more guys shall be provided. Pole bands shall be provided where guy tension exceeds 10,000 pounds. Guy clamps 6 inches in length with three 5/8-inch bolts, or offset-type guy clamps, or approved guy grips shall be provided at each guy terminal. Torque all connections to a minimum 2500 ft-lbs, or as specified.

B. Anchors shall be of an expanding type with a minimum diameter of 8 inches. Multiple-helix screw anchors shall be provided in marshy ground. Rock anchors shall be installed in rock at right angles to guys.

3.09 INSULATORS

A. Suspension Insulators: Suspension insulators shall be installed at corners, angles, and dead-ends as indicated, and other areas where line insulators do not provide adequate strength. Mechanical strength of suspension insulators and hardware shall exceed the rated breaking strength of the conductors attached thereto.

B. Medium-Voltage Line Insulators: Medium-voltage line insulators shall have ratings not lower than the ANSI classes indicated in Table VI "Minimum ANSI C29 Rating of Medium-Voltage Insulators by Class". Horizontal line-type post insulators shall be used for armless construction and shall have the same mechanical and electrical ratings as vertical line-type post insulators for the ANSI class indicated, but shall be modified to be suitable for horizontal installation. Where line-post insulators are used for angles greater than 15 degrees, clamp-top fittings shall be provided as well as for other locations shown. Conductor clamps for use with clamp-top, line-post insulators shall be hot-dip galvanized malleable iron for copper conductors and aluminum alloy for aluminum-composition conductors. Pin insulators for use on voltages in excess of 6,000 volts phase-to-phase shall be radio-interference-free or else line-post insulators shall be used.

C. Low-Voltage Line Insulators: Spool insulators for use on low-voltage lines shall be mounted on clevis attachment and shall be not smaller than Class 53-2. For 4/0 AWG and larger conductors Class 53-4 shall be used. Suspension insulators on clevis attachments used at dead-ends shall be not smaller than Class 52-1.

D. Guy Wire Insulators: Fiberglass strain guy insulators for use in insulated guy assemblies shall have a mechanical strength exceeding the rated breaking strength of the guy attached thereto. Insulators shall be not smaller than Class 54-1 for lines up to 5 kV, not smaller than Class 54-2 for lines of 6 kV to 15 kV, not smaller than Class 54-4 for lines of 16 kV to 25 kV.

E. Series Roadway Lighting Insulators: Pin insulators shall be Class 55-5; line-post insulators shall be Class 57-1 or 57-11.

3.10 LIGHTING

A. Floodlights: Floodlights shall be of the enclosed heavy-duty type having indicated beam spreads and adjustable support brackets suitable for required mountings. Mountings and brackets shall be as indicated. Floodlights shall be equipped with weatherproof plug-in or twist-lock receptacles to receive photo-control elements. Lamps shall be of the sizes and types indicated and provided with appropriate ballasts.

B. Luminaires: Luminaires shall be of the enclosed type each consisting of a cast aluminum housing, a finished aluminum reflector for corrosion protection, an enclosing glass refractor or globe providing the indicated IES RP-8 type light distributions, and a slip-fitter capable of adapting to 1-1/4 inch through 2-inch mounting brackets. Luminaire heads shall have standard dimensions suitable for interchangeable, standard optical assemblies. Heads shall be internally wired and rated 600 volts. Luminaires shall be equipped with weatherproof plug-in or twist-lock receptacles to receive photo-control elements. Lamps shall be of the sizes and types indicated and provided with appropriate ballasts.

C. Brackets: Brackets on wood poles shall be galvanized-steel pipe or equivalent aluminum secured to poles with through-bolts and lag screws as required for load

support. Brackets on metal poles shall be of the same type of metal as the pole. Brackets shall correctly position luminaires not less than the indicated number of feet from poles, at not less than the mounting heights indicated, but in no case less than 24 feet above any roadway. Slipfitter brackets shall be coordinated with the luminaires provided, and brackets used with one type of luminaire shall be identical.

D. Vandal-Resistant Construction: Where indicated, luminaires shall be provided with vandal-resistant construction. Exposed diffusers, reflectors, or refractors shall be of a polycarbonate resin, except that other material may be used if protected by a polycarbonate resin shield or cast metal guard. Luminaires mounted 15 feet and less above grade shall have exposed screws of the tamper-resistant type.

E. Photo-Control: Luminaires shall be controlled by a contactor unless specified otherwise on the contract drawings. Each photo-control element shall have an adjustable operating range of approximately 0.5 to 5.0 foot-candles and shall be mounted in a receptacle, weatherproof, plug-in or twist-lock assembly.

3.11 POLES

A. General Pole Line Installation Requirements

1. Joint-use electric/roadway-lighting poles for overhead electric and communication lines shall be as specified on drawings utilizing armless construction. Cluster-mounted banked single-phase transformer installations shall be provided. Pole equipment mounts rather than crossarm equipment mounts may be utilized if shop drawings are submitted and approved.

2. Provision for Communication Services: Provision for communication services is required on pole-line construction, except where specifically noted otherwise. A vertical pole space of not less than 2 feet below the neutral and 6 feet from the nearest primary conductor, or as according to NESC Article 233 C3, shall be reserved at indicated locations.

3. Poles shall be of lengths and class indicated on drawings. Design clearances must be maintained.

B. Wood Poles

1. Storage and Handling of Poles

a. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ANSI 05.1. Poles shall be stacked on treated skids, so arranged as to support the poles without producing noticeable distortion to any of the poles and to allow free circulation of air. The height of the piles shall be limited so as to avoid damage to poles on the bottom layers. Poles shall be piled and supported in such a manner that all poles are at least 1 foot above general ground level and any vegetation growing thereon. No decayed or decaying wood shall be permitted to remain underneath stored poles.

b. Handling of wood poles shall be in accordance with ANSI 05.1. Poles shall not be dragged along the ground. Cant hooks, pole tongs, or other tools

capable of producing indentations of more than 1 inch in depth shall not be used in handling the poles.

2. Wood Pole Setting

a. Poles shall be set vertically except at angles, dead ends, or where guyed; in which case, they shall be raked 3 inches per 5 feet of pole height away from the direction of pull, prior to the attachment of conductors. The pole shall retain some rake and shall not be less than vertical after the conductors are installed. On straight runs, the poles shall be carefully aligned with crossarms at right angles to the direction of line. When practicable, the crossarms, braces, and other fixtures shall be mounted on the pole before erection.

b. Poles shall be set to maintain as even a grade as practicable. When the average ground run is level, consecutive poles shall not vary more than 5 feet in height per 100 feet. When the ground is uneven, poles differing in length shall be kept to a minimum by locating poles to avoid the highest and lowest ground points. The conductor ground clearances shall be maintained as indicated on the drawings. If the clearance cannot be maintained, a taller pole shall be utilized to achieve the clearance. If it becomes necessary to shorten a pole, a piece shall be sawed off the top end with a 15° one-way roof. Gains and holes that are cut during erection shall be retreated by application of the original preservative or a SDR approved substitute.

c. Poles shall be set in the ground to the depth indicated on the drawings or as designated in Table VII "Minimum Pole-Setting Depth". In rocky ground, pole-setting depths may be decreased with the approval of the SDR. Holes shall be dug a minimum of 12 inches greater than the diameter of the pole to permit proper use of tampers to the full depth of a hole. Backfilling shall be done with earth or crushed rock, free from vegetable matter or other material that will shrink. Earth shall be placed into a hole in 6 inch maximum layers, then thoroughly tamped before the next layer is placed. Surplus earth shall be placed around a pole in a conical shape and packed tightly to drain water away from poles. Where poles are set on hilly terrain, along edges of cuts or embankments, or where soil may be washed out, special precautions shall be taken to ensure durable pole foundations, and the setting depth shall be measured from the lower side of the pole.

C. Steel Poles

1. Steel poles shall be handled and stored in accordance with the manufacturer's instructions.

2. Steel Pole Setting: Concrete foundations shall have anchor bolts accurately set in foundations using a template supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03300, “Cast-In-Place Concrete”. When concrete has cured, base plates shall be leveled and grouted in place. Pole anchor bases shall then be set on base plates, leveled plumb on foundations, and secured with the holding nuts. Install a copper-clad steel ground rod, not less than 5/8-inch in diameter by 8 feet in length, for each base.

3.12 POLE LINE HARDWARE

A. Armless Construction: Pole mounting brackets for line-post insulators and eye bolts for suspension insulators shall be installed so as to provide not less than the required climbing space. Brackets shall be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of a pole. Brackets for wood poles shall have wood gripping members. For horizontal offsets use MF brackets. Pole top brackets shall conform to ANSI C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than a 2,800 pounds cantilever strength.

B. Hardware: Pole-line hardware shall be hot-dip galvanized steel. Suitable washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 2-1/4 inches square and 3/16 inch thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Square curved washers shall be used for down-guy attachments to pole. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises shall be used wherever required to adequately support and protect poles, brackets, crossarms, guy wires, and insulators.

C. Metal pins shall be zinc-coated forged steel with lead thread height to suit the insulator provided, but not less than 6 inches high by 3/4 inch diameter. The head of the pin shall be not less than 2 inch diameter, designed to distribute load uniformly to the crossarm. Shank shall be not less than 3/4 inch diameter by 5-3/4 inch length, equipped with 2-inch-square washer, nut, and locknut, and shall project not less than 1/8 inch nor more than 2 inches beyond locknut.

D. Apparatus: Apparatus shall be grounded as specified in Section 3.06: GROUNDING AND BONDING.

3.13 TESTS

A. Operating Test: After the installation is completed, the Contractor shall conduct an operating test for approval. Equipment shall be demonstrated to operate in accordance with the requirements herein. Tests shall be performed in the presence of the SDR. The Contractor shall furnish instruments and personnel required for the test, and Sandia National Laboratories will furnish the necessary electric power.

B. Ground-Resistance Measurements: Ground-resistance measurements of each ground rod shall be taken and certified by the Contractor to the SDR. No part of the electrical distribution system shall be energized prior to the resistance testing of that system's ground rods and grounding systems and submission of test results to the SDR. Test reports shall indicate the location of the ground rod and grounding system and the resistance and the soil conditions at the time the test was performed. When the building water service is used as a ground or part of the grounding system, ground-resistance measurements shall also be made of this connection. Ground-resistance measurements shall be made in normally dry weather, not less than 48 hours after rainfall, and with the ground under test isolated from other grounds. The resistance to ground shall be measured using the fall-of-potential method described in IEEE No. 142.

C. Medium-Voltage Preassembled Cable Test: Medium voltage cable tests shall be done in conformance with Section 16124, "Medium Voltage Cable".

D. Sag and Tension Test

1. The SDR shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

2. The Contractor shall submit the sag and tension method to be used (stop-watch return wave or transite) and the sag tables used to achieve the proper sag. The contractor shall wait a minimum of 2 hours after stringing the conductors to allow the conductors to stabilize prior to conducting the sag and tension tests. The contractor must complete the tests within 36 hours after stringing the conductors to avoid damaging the cable. Sagging operations shall not be conducted when wind conditions prevents satisfactory sagging.

3. The span used to set the sag shall be called the sag-check span. The sag-check span shall be a level span and approximately equal to the ruling span. The ruling span will be indicated on construction documents or by the SDR.

4. The sag of more than ten spans shall be checked at least two sag-check spans, preferably one near each end of the line. At all angles over 10° the sag shall be checked at both sides of the angle. A deadend span shall not be used as a sag-check span.

3.14 TRANSFORMERS, OVERHEAD

A. Overhead distribution transformers shall be of the two-winding per phase, outdoor, oil-immersed type, single-phase as indicated. Transformers shall be provided with necessary auxiliary mounting devices suitable for the indicated installation.

B. Transformers shall be carefully installed so as not to scratch finishes or damage bushings. After installation, surfaces shall be inspected and scratches touched up with a finish furnished by the transformer manufacturer for this purpose.

C. The transformer kVA shall be painted on the transformer case such that the kVA rating can be read from the ground.

TABLE I. OVERHEAD CONDUCTOR LOADING

Temperature (°F)	Ice (radial in.)	Wind (lbs.)	Tension (% (3))	Code
15.0	0.25	4.00	0.250	1
0.0			0.200	2
0.0			0.170	2
60.0				

Code	Meaning
1	- Initial Tension (Sag) Limit
2	- Final Tension (Sag) Limit
3	- Percentage of Ultimate Conductor Strength

TABLE II. MAXIMUM ALLOWABLE CHECK DIMENSIONS

Length of Pole	Maximum Width	Maximum Length
30 feet	1/4 inch	5 feet
35 and 40 feet	5/16 inch	5 feet
45 nd 50 feet	3/8 inch	8 feet

TABLE III. MAXIMUM ALLOWABLE KNOT DIMENSIONS

Pole Length	Diameter of Any Single Knot	Sum of Diameters of Knots in Any 1-Foot Section
45 feet and shorter	2.5 inches	8 inches
50 feet	3.0 inches	10 inches

TABLE IV. TIE WIRE REQUIREMENTS

Copper AWG	Soft-Drawn Copper AWG
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2

AAC, AAAC, or ACSR AWG	AWG
2 and less	6 AAAC
2/0 and up	4 AAC

TABLE V. NETA BOLT TORQUES FOR BUS CONNECTIONS

Heat Treated Steel-Cadium or Zinc Plated

Grade	SAE 1 & 2	SAE 5	SAE 6	SAE 8
Minimum Tensile (P.S.I)	64K	105K	133K	150K
Bolt Diameter	Torque (Foot Pounds)			
1/4	4.0	5.6	8.0	8.4
5/16	7.2	11.2	15.2	17.6
3/8	12.0	20.0	27.2	29.6
7/16	19.2	32.0	44.0	48.0
9/16	42.4	70.4	96.0	105.6
5/8	59.2	96.0	133.6	144.0
3/4	96.0	160.0	224.0	236.8
7/8	152.0	241.6	352.0	378.4
1.0	225.6	372.8	528.0	571.2

Silicon Bronze Fasterners *

	Torque (Foot Pounds)	
Bolt Diameter	Non-Lubricated	Lubricated
5/16	15	10
3/8	20	14
1/2	40	25
5/8	55	40
3/4	70	60

* Bronze alloy bolts shall have a minimum tensile strength of 70,000 pounds per square inch.

Aluminum Alloy Fasterners **

	Torque (Foot Pounds)
Bolt Diameter	Lubricated
5/16	8.0
3/8	11.2
1/2	20.0
5/8	32.0
3/4	48.0

** Aluminum alloy bolts shall have a minimum tensile strength of 55,000 pounds per square inch.

bolts, capscrews, flat washers:	2024-T4 alloy
nuts:	6061-T6 alloy
lock washers:	7075-t6 alloy

TABLE V. NETA BOLT TORQUES FOR BUS CONNECTIONS (CON'T)

Stainless Steel Fasterners ***

Bolt Diameter	Torque (Foot Pounds) Uncoated
5/16	14
3/8	25
1/2	45
5/8	60
3/4	90

*** bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy
Belleville washers: 302 alloy

TABLE VI. MINIMUM ANSI C29 RATING OF MEDIUM-VOLTAGE INSULATORS BY CLASS

Voltage Level	Line-Post	Pin	Suspension
Up to 5 kV	57-1 or 11	55-3	One 52-1
6 kV to 15 kV	57-1 or 11	55-5	Two 52-2
16 kV	57-2 or 12	56-3	Two 52-3 or 4
26 kV to 35 kV	57-3 or 13	56-4	Three 52-3 or 4

TABLE VII. MINIMUM POLE-SETTING DEPTH

	Setting depth in soil (ft-in)		Setting depth in rock (ft-in)	
Length of Pole (ft)	Straight Lines	Angle-poles, Corners, and Points of Extra Strain	Straight Lines	Angle-poles, Corners, and Points of Extra Strain
20	5-0	5-0	3-0	3-6
25	5-0	5-6	3-6	4-0
30	5-6	6-0	3-6	4-0
35	6-0	6-6	4-0	4-6
40	6-0	6-6	4-0	4-6
45	6-6	7-0	4-6	5-0
50	7-0	7-6	4-6	5-0
55	7-6	8-0	5-0	5-6
60	8-0	8-6	5-0	5-6
65	8-0	9-0	6-0	6-6
70	9-0	9-6	6-0	6-6
75	9-6	10-0	6-0	6-6
80	10-0	10-6	6-6	7-0
85	10-6	11-0	7-0	7-6
90	11-0	11-6	7-6	8-0
95	11-0	11-6	7-6	8-0
100	11-0	11-6	7-6	8-0

NOTES: The general rule for determining the setting depth in soil is to take 10 percent of the pole length and add 2 ft.

For example 10% of 40' = 4ft + 2ft = 6ft.

Holes for poles set on a slope shall be 1/2 ft. deeper than normal, measured from the lowest point on the ground.

END OF SECTION 16401