DIVISION 26

ELECTRICAL

SECTION 26 05 13
MEDIUM VOLTAGE CABLE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Medium voltage cable (601 V and above).
      b. Cable terminations and splices.

B. Related Specification Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical - Basic Requirements.
   2. Section 26 05 19 - Wire and Cable - 600 Volt and Below.
   3. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Association of Edison Illuminating Companies (AEIC).
      a. CS8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 48, Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.
      b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV.
      c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV.
   3. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
      a. WC 74/S-93-639, 5 - 46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   5. Underwriters Laboratories, Inc. (UL):
      a. 1072, Standard for Medium-Voltage Power Cables.

B. Qualifications:
   1. Cable technician:
      a. Three years of experience in handling, terminating and splicing medium voltage cables.
      b. Specifically trained by a factory representative on the terminations and splices to be used on the project.
         1) If not trained on the products to be used, on-site training by the factory representative shall be performed before any terminations or splices are made.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   2. Fabrication and/or layout drawings:
      a. Cable pulling plan.

B. Informational Submittals:
   1. Cable pulling tension measurements or photograph of breakaway swivel attached to cable.
   2. Submit the following before terminating cables:
      a. Cable Technician qualifications.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Ship cable with removable watertight end seals, and store in dry place.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Wire and cable:
      a. General Cable.
      b. The Kerite Company.
      c. The Okonite Company.
      d. Prysmian Group.
      e. Southwire Company.
   2. Lugs, connectors and terminations:
      a. 3M.
      b. Elastimold by Thomas & Betts.
      c. Joslyn.
      d. TE Connectivity Raychem.
      e. Eaton Cooper Power Systems.

2.2 MEDIUM VOLTAGE CABLES

A. Ratings:
   1. Voltage class as indicated on the Drawings.

B. Standards:
   1. NEMA/ICEA WC 74/S-93-639.
   2. AEIC CS8.
   3. UL 1072.

C. Conductor Material:
   1. Compact stranded copper.

D. Insulation:
   1. Temperature rating: Type MV-90 or MV-105 per NFPA 70.
   2. Cross-linked thermosetting polyethylene (XLP).
   3. 133% insulation level.

E. Shielding:
   1. Shielding on cables rated above 2 kV consists of:
      a. Semiconductor conductor screen.
      b. Semiconductor insulation screen.
      c. [Copper tape or copper wire] [Copper concentric neutral].

F. Neutrals:
   1. [Cables with a concentric neutral shall have [full] [1/3] concentric neutral] [Neutral conductors of grounded neutral systems indicated on the drawings, shall be of the same insulation materials as the phase conductors, except with a 600 V insulation rating].

G. Grounds:
   1. Insulated copper per Specification Section 26 05 19.

H. Jackets:

1. Direct buried cables shall be rated for direct bury.
2. Jacket: [PVC] [Polyethylene].

2.3 CABLE ACCESSORIES

A. Lugs and Connectors:
   1. Lugs:
      a. Compression type.
      b. Standard: [UL 486A for copper cables] [UL 486B for aluminum and copper cables].
      c. Voltage rating: Up to 35 kV.
      d. Current rating: Continuous operation at the rating of the cable.
      e. Material: [Tin-plated copper] [Aluminum with bronze underplating, tin outerplating and aluminum anti-oxide paste].
      f. Number of holes: Two, except one on motor leads.
   2. Splice connectors:
      a. Standard: [UL 486A for copper cables] [UL 486B for aluminum and copper cables].
      b. Voltage rating: Up to 35 kV.
      c. Current rating: Continuous operation at the rating of the cable.
      d. Material: [Tin-plated copper] [Aluminum with bronze underplating, tin outerplating and aluminum anti-oxide paste].

B. Terminations:
   1. End caps:
      a. Cold or hot shrink.
      b. Used to environmentally seal and mechanically protect exposed cable ends.
   2. Cold shrink kits:
      a. Standard: IEEE 48, Class 1 termination.
      b. Voltage rating: Same as the cable rating.
      c. Current rating: Continuous operation at the rating of the cable.
      d. One-piece design, where high-dielectric constant stress control is integrated within a skirted insulator made of silicone rubber.
      e. Suitable for contaminated indoor and outdoor locations.
   3. Molded rubber kit:
      a. Standard: IEEE 48.
      b. Voltage rating: Same as the cable rating.
      c. Current rating: Continuous operation at the rating of the cable.
      d. One-piece design or modular with stress cone and skirts, where high-dielectric constant stress control is integrated within a skirted insulator made of EPDM rubber.
      e. Suitable for contaminated indoor and outdoor locations.
   4. Elbow connectors:
      a. Standard: IEEE 386.
      b. Voltage rating: Same as the cable rating.
      c. Current rating: 200A.
      d. One-piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
      e. Deadfront, loadbreak type with:
         1) Hot stick pulling eye.
         2) Grounding tab.
         3) [No test point] [Test point].
      f. Accessories to be constructed in a similar manner as the elbow connector:
         1) Bushing inserts.
         2) Bushing well plugs.
         3) Feed thru inserts.
         4) Protective caps.

C. Splices:
   1. Cold shrink kits:

a. Standard: IEEE 404.
b. Voltage rating: Same as the cable rating.
c. Current rating: Continuous operation at the rating of the cable.
d. One-piece design, comprised of an insulation shield, insulation layer and a silicone rubber body.
e. Suitable for indoor, direct burial or submersible applications.

2. Molded rubber kit:
a. Standard: IEEE 386 or IEEE 404.
b. Voltage rating: Same as the cable rating.
c. Current rating: Continuous operation at the rating of the cable.
d. One- or multi-piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
e. Suitable for indoor, direct burial or submersible applications.

3. Modular separable molded rubber:
a. Standard: IEEE 386.
b. Voltage rating: Same as the cable rating.
c. Current rating: 600A.
d. One-piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
e. Deadfront, deadbreak type.
f. Components: T-body, insulating plug with cap, insulating plug with cap and stud, and connecting plug.
g. Suitable for submersible applications.

4. Motor lead kits:
a. Voltage rating: Same as the cable rating.
b. Current rating: Continuous operation at the rating of the cable.
c. Material: EPDM rubber boot with nylon pin.
d. On shielded cables provide and additional EPDM rubber cold shrink sleeve.

D. Cable Shield Grounding Adapters:
1. Type: Molded rubber with constant force spring and solder-blocked tinned copper braid pigtail.
2. Waterproof, providing a positive seal for the cable jacket.
3. May be integral with termination of splice device with Engineer's approval.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not install cable during wet conditions.
1. Prior to pulling cables, drain or pump out manholes and other low points if standing water is present.
2. Blow out conduits with dried compressed air if moisture is present in conduits.
3. Install end caps immediately on all cut ends of cable prior to pulling, and maintain end caps while pulling in cable.
a. If end caps are damaged, remove and install new end caps.
b. Do not remove end caps until ready to terminate or splice cable.

B. Cable Installation in Manholes:
1. Arc-proof all cables in manholes.
a. Apply in spiral, half-overlap fashion to full exposed length of each cable in manhole.
b. Secure in place with glass cloth electrical tape.
1) Apply in reverse spiral to arc-proofing tape, at maximum interval of 9 IN and double wrapped at each end.

C. Do not install conductors when ambient temperature is near minimum as recommended by manufacturer for installation of the type of conductor insulation.

D. Provide components in kit form, complete with instructions, supplied by a single approved manufacturer and suitable for each shielded cable termination.
   1. Select correct termination to match cable diameter and construction.
   2. Form and install terminations in strict accordance with instructions of cable manufacturer and termination manufacturer.

E. Splices:
   1. Provide components in kit form, complete with instructions, supplied by a single approved manufacturer and suitable for the type of cable being used.
   2. Prepare cable ends, provide materials and follow all application steps in accordance with manufacturer's instructions.
      a. As a minimum requirement:
         1) The cable ends shall be cut squarely.
         2) The insulation shall be free from nicks or burrs after removal of jacket.
         3) The conductors shall be cleaned and an oxide inhibitor applied.
         4) For splices, connector indents shall be filled with insulating putty to eliminate voids or prepared per manufacturer's instructions.
         5) Attach grounding lead to system ground.
   3. Splices shall be avoided whenever possible.
      a. No more than one splice is permitted between termination points without Engineer's approval.
      b. No splices are permitted in runs less than 100 FT long.
      c. Splices will be made only at manholes or other accessible locations.
      d. Do not pull splices into ductbanks or conduits or leave them under tension.

F. The ground shield grounding adaptors shall be grounded:
   1. Shirted and elbow terminators: Grounded to ground bar or cable loop in equipment.
   2. Splices: Grounded to ground bar or rod in manhole.
   3. Connect with insulated, stranded #6 AWG wire.

3.2 FIELD QUALITY CONTROL

A. Cable pulling plan.
   1. Underground ductbanks: Include proposed splice points, cable pulling direction for each pull, and estimated pulling tensions (tension calculation).
      a. Include unreeling tensions, sheave radius, lubrication coefficient of friction, etc. in the calculation.
      b. Identify any cable pulling aids necessary to not over tension the cable during the pull. For example: motorized cable reel roller, lubrication quantity.
      c. Identify all devices to be used to attach cables to puller. For example, wire grips, swivels, slings.
      d. [Include all cables] [Include pulls longer than [____] FT] [Include cable numbers [_____].
   2. Above grade raceways: Include proposed splice points, cable pulling direction for each pull, and estimated pulling tensions (tension calculation).
      a. Include pull box sizing calculations.
      b. Identify any cable pulling aids necessary to not over tension the cable during the pull. For example, cable reel roller, lubrication quantity.
      c. Identify all devices to be used to attach cables to puller. For example, wire grips, swivels, slings.
      d. [Include all cables] [Include pulls longer than [____] FT] [Include cable numbers [_____].

B. When estimated pulling tension is greater than 75% of cables maximum allowed tension, provide measurement of tensions during the pull or use breakaway swivel of a strength less than the cable's maximum allowed tension.

C. See Specification Section 26 08 13 for acceptance testing requirements.

END OF SECTION

SECTION 26 05 19
WIRE AND CABLE - 600 VOLT AND BELOW

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Building wire.
      b. Power cable.
      c. Control cable.
      d. Instrumentation cable.
      e. Wire connectors.
      f. Pulling lubricant.

B. Related Specification Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Insulated Cable Engineers Association (ICEA):
      a. S-58-679, Standard for Control Cable Conductor Identification.
   2. National Electrical Manufacturers Association (NEMA):
      a. ICS 4, Industrial Control and Systems: Terminal Blocks.
   3. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
      a. WC 57/S-73-532, Standard for Control Cables.
      b. WC 70/S-95-658, Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
   5. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
      a. 568, Commercial Building Telecommunications Cabling Standard.
   6. Underwriters Laboratories, Inc. (UL):
      a. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
      b. 83, Standard for Safety Thermoplastic-Insulated Wires and Cables.
      c. 467, Standard for Safety Grounding and Bonding Equipment.
      d. 486A, Standard for Safety Wire Connectors and Soldering Lugs for use with Copper Conductors.
      e. 486C, Standard for Safety Splicing Wire Connections.
      f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
      g. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
      h. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.
      i. 2250, Standard for Safety Instrumentation Tray Cable.

1.3 DEFINITIONS

A. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.

B. Instrumentation Cable:
   1. Multiple conductor, insulated, twisted or untwisted, with outer sheath.
   2. The following are specific types of instrumentation cables:
      a. Analog signal cable:
         1) Used for the transmission of low current (e.g., 4-20mA DC) or low voltage (e.g., 0-10 VDC) signals, using No. 16 AWG and smaller conductors.
         2) Commonly used types are defined in the following:
            a) TSP: Twisted shielded pair.
            b) TST: Twisted shielded triad.
      b. Digital signal cable: Used for the transmission of digital signals between computers, PLC's, RTU's, etc.

C. Power Cable: Multi-conductor, No. 8 AWG and larger.

D. Control Cable: Multi-conductor, insulated, and jacketed, No. 14, No. 12 or No. 10 AWG.

E. Building Wire: Single conductor, insulated, with or without outer jacket depending upon type.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
         1) Wire connectors.
         2) Cable lubricant.
      b. See Specification Section 26 05 00 for additional requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Building wire, power and control cable [and multiplex cable]:
      a. Aetna Insulated Wire.
      b. Alphawire.
      c. Cerrowire.
      d. Encore Wire Corporation.
      e. General Cable.
      f. Okonite Company.
      g. Southwire Company.
   2. Instrumentation cable:
      a. Analog cable:
         1) Alphawire.
         2) Belden Inc.
         3) General Cable.
   3. Wire connectors:
      a. Burndy Corporation.
      b. Buchanan.
      c. Ideal.
      d. Ilsco.
      e. 3M Co.
      f. Teledyne Penn Union.
      g. Thomas and Betts.

h. Phoenix Contact.

4. Insulating and color coding tape:
   a. 3M Co.
   b. Plymouth Bishop Tapes.
   c. Red Seal Electric Co.

2.2 MANUFACTURED UNITS

A. Power Cable:
   1. Conductor shall be copper with 600 V rated insulation.
   2. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
   3. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 and UL 1277 for type THHN/THWN insulation with an overall PVC jacket.
   4. Conform to NEMA/ICEA WC 70/S-95-658 and UL 44 and UL 1277 for type XHHW-2 insulation with an overall PVC jacket.
   5. Number of conductors as required, including a bare ground conductor.
   6. Individual conductor color coding:
      a. ICEA S-58-679, Method 4.
      b. See PART 3 of this Specification Section for additional requirements.
   7. Conform to NFPA 70 Type TC [and IEEE 1202 or CSA FT-4].

B. Control Cable:
   1. Conductor shall be copper with 600 V rated insulation.
   2. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
   3. Conform to NEMA/ICEA WC 57/S-73-532 and UL 83 and UL 1277 for type THHN/THWN insulation with an overall PVC jacket.
   4. Conform to NEMA/ICEA WC 57/S-73-532 and UL 44 and UL 1277 for type XHHW-2 insulation with an overall PVC jacket.
   5. Number of conductors as required, provided with or without bare ground conductor of the same AWG size.
      a. When a bare ground conductor is not provided, an additional insulated conductor shall be provided and used as the ground conductor (e.g., 6/c No. 14 w/g and 7/c No. 14 are equal).
   6. Individual conductor color coding:
      a. ICEA S-58-679, Method 1, Table E-2.
      b. See PART 3 of this Specification Section for additional requirements.
   7. Conform to NFPA 70 Type TC and IEEE 1202, NFPA 262].

C. Electrical Equipment Control Wire:
   1. Conductor shall be copper with 600 V rated insulation.
   2. Conductors shall be stranded.
   3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
   4. Conform to UL 44 for Type SIS insulation.
   5. Conform to UL 83 for Type MTW insulation.

D. Instrumentation Cable:
   1. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
   2. Analog cable:
      a. Tinned copper conductors.
      b. 300 V or 600 V PVC insulation with PVC jacket.
      c. Twisted with 100% foil shield coverage with drain wire.
      d. Six (6) twists per foot minimum.
      e. Individual conductor color coding: ICEA S-58-679, Method 1, Table E-2.

f. Conform to [IEEE 1202 or CSA FT-4 or NFPA 262,] UL 2250, UL 1581 and NFPA 70 Type ITC.

3. Digital cable:
   a. As recommended by equipment (e.g., PLC, RTU) manufacturer.
   b. Horizontal voice and data cable:
      1) Category 6 per TIA/EIA/ANSI 568.
      2) Cable shall be label-verified.
      3) Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level.
      4) Conductors: No. 24 AWG solid untinned copper.
      5) Rated CMP per NFPA 70.

E. Wire Connectors:
   1. Twist/screw on type:
      a. Insulated pressure or spring type solderless connector.
      b. 600 V rated.
      c. Ground conductors: Conform to UL 486C and/or UL 467 when required by local codes.
      d. Phase and neutral conductors: Conform to UL 486C.
   2. Compression and mechanical screw type:
      a. 600 V rated.
      b. Ground conductors: Conform to UL 467.
      c. Phase and neutral conductors: Conform to UL 486A.
   3. Terminal block type:
      a. High density, screw-post barrier-type with white center marker strip.
      b. 600 V and ampere rating as required, for power circuits.
      c. 600 V, 20 ampere rated for control circuits.
      d. 300 V, 15 ampere rated for instrumentation circuits.
      e. Conform to NEMA ICS 4 and UL 486A.

F. Insulating and Color Coding Tape:
   1. Pressure sensitive vinyl.
   2. Premium grade.
   3. Heat, cold, moisture, and sunlight resistant.
   4. Thickness, depending on use conditions: 7, 8.5, or 10 MIL.
   5. For cold weather or outdoor location, tape must also be all-weather.
   6. Color:
      a. Insulating tape: Black.
      b. Color coding tape: Fade-resistant color as specified herein.
   7. Comply with UL 510.

G. Pulling Lubricant: Cable manufacturer's standard containing no petroleum or other products which will deteriorate insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Permitted Usage of Insulation Types:
   1. Type XHHW-2:
      a. Building wire and power and control cable in architectural and non-architectural finished areas.
      b. Building wire and power and control cable in conduit in outdoor areas and below grade.
      c. Building wire and power and control cable in cable tray in outdoor areas.
   2. Type THHN/THWN and THHN/THWN-2:
      a. Building wire and power and control cable No. 8 AWG and smaller in architectural and non-architectural finished areas.

3. Type SIS and MTW:
    a. For the wiring of control equipment within control panels and field wiring of control equipment within switchgear, switchboards, motor control centers.

B. Conductor Size Limitations:
1. Feeder and branch power conductors shall not be smaller than No. 12 AWG unless otherwise indicated on the Drawings.
2. Control conductors shall not be smaller than No. 14 AWG unless otherwise indicated on the Drawings.
3. Instrumentation conductors shall not be smaller than No. 18 AWG unless otherwise indicated on the Drawings.

C. Color Code All Wiring as Follows:
1. Power cables ICEA S-58-679, Method 4 with:
    a. Phase and neutral conductors identified with 3 IN of colored tape, per the Table herein, applied at the terminations.
    b. Ground conductor: Bare.
2. Control cables ICEA S-58-679, Method 1, Table E-2:
    a. When a bare ground is not provided, one of the colored insulated conductors shall be re-identified by stripping the insulation from the entire exposed length or using green tape to cover the entire exposed length.
    b. When used in power applications the colored insulated conductors used as phase and neutral conductors may have to be re-identified with 3 IN of colored tape, per the Table herein, applied at the terminations.

D. Install all wiring in raceway unless otherwise indicated on the Drawings.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing:
1. See Specification Section 26 08 13.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for grounding and bonding system(s).

B. Related Specification Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical - Basic Requirements.
   2. Section 26 05 19 - Wire and Cable - 600 Volt and Below.
   3. Section 26 05 33 - Raceways and Boxes.
   4. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL):
      a. 467, Grounding and Bonding Equipment.

B. Assure ground continuity is continuous throughout the entire Project.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data.
      a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
         1) Grounding clamps, terminals and connectors.
         2) Exothermic welding system.
      b. See Specification Section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Ground rods and bars and grounding clamps, connectors and terminals:
      a. ERICO by Pentair.
      b. Harger Lightning & Grounding.
      c. Heary Bros. Lightning Protection Co. Inc..
      d. Burndy by Hubbell.
      e. Robbins Lightning, Inc.
      f. Blackburn by Thomas & Betts.
      g. Thompson Lightning Protection, Inc.
   2. Exothermic weld connections:
      a. ERICO by Pentair - Cadweld.

b. Harger Lightning & Grounding - Ultraweld.
c. Burndy by Hubbell - Thermoweld.
d. FurseWELD by Thomas & Betts.

2.2 COMPONENTS

A. Wire and Cable:
1. Bare conductors: Soft drawn stranded copper meeting ASTM B8.
2. Insulated conductors: Color coded green, per Specification Section 26 05 19.

B. Conduit: As specified in Specification Section 26 05 33.

C. Ground Bars:
1. Solid copper:
a. 1/4 IN thick.
b. 2 or 4 IN wide.
c. 24 IN long minimum in main service entrance electrical rooms, 12 IN long elsewhere.
2. Predrilled grounding lug mounting holes.
3. Stainless steel or galvanized steel mounting brackets.
4. Insulated standoffs.

D. Ground Rods:
1. 5/8 IN x 10 FT or as indicated on the Drawings.
2. Copper-clad:
a. 10 MIL minimum uniform coating of electrolytic copper molecularly bonded to a rigid steel core.
b. Corrosion resistant bond between the copper and steel.
c. Hard drawn for a scar-resistant surface.

E. Grounding Clamps, Connectors and Terminals:
1. Mechanical type:
a. Standards: UL 467.
b. High copper alloy content.
2. Compression type for interior locations:
a. Standards: UL 467.
b. High copper alloy content.
c. Non-reversible.
d. Terminals for connection to bus bars shall have two bolt holes.
3. Compression type suitable for direct burial in earth or concrete:
a. Standards: UL 467, IEEE 837.
b. High copper alloy content.
c. Non-reversible.
d. Factory filled with oxide inhibiting compound.

F. Exothermic Weld Connections:
1. Copper oxide reduction by aluminum process.
2. Molds properly sized for each application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
1. Install products in accordance with manufacturer's instructions.
2. Size grounding conductors and bonding jumpers in accordance with NFPA 70, Article 250, except where larger sizes are indicated on the Drawings.
3. Remove paint, rust, or other non-conducting material from contact surfaces before making ground connections. After connection, apply manufacturers approved touch-up paint to protect metallic surface from corrosion.

4. Where ground conductors pass through floor slabs or building walls provide nonmetallic sleeves and install sleeve per Specification Section 01 73 20.
    a. Seal the sleeve interior to stop water penetration.
5. Do not splice grounding electrode conductors except at ground rods.
6. Install ground rods and grounding electrode conductors in undisturbed, firm soil.
    a. Provide excavation required for installation of ground rods and conductors.
    b. Use driving studs or other suitable means to prevent damage to threaded ends of sectional rods.
    c. Unless otherwise specified, connect conductors to ground rods with compression type connectors or exothermic weld.
    d. Provide sufficient slack in conductor to prevent conductor breakage during backfill or due to ground movement.
    e. Backfill excavation completely, thoroughly tamping to provide good contact between backfill materials and ground rods and conductors.
7. Do not use exothermic welding if it will damage the structure the grounding conductor is being welded to.

B. Grounding Electrode System:
1. Provide a grounding electrode system in accordance with NFPA 70, Article 250 and as indicated on the Drawings.
    a. All grounding electrode conductors terminate on a main ground bar located adjacent to the service entrance equipment.
2. Grounding electrode conductor terminations:
    a. Ground bars mounted on wall: Use a two-hole compression type conductor terminal and bolt it to the ground bar with two bolts.
    b. Ground bars in electrical equipment: Use compression type conductor terminal and bolt it to the ground bar or manufacture's provided mechanical type termination device.
    c. Piping systems: Use mechanical type connections.
    d. Building steel, below grade and encased in concrete: Use compression type connector or exothermic weld.
    e. Building steel, above grade: Use a two-hole compression type conductor terminal and bolt to the steel with two bolts or exothermic weld.
    f. Ground rod: Compression type or exothermic weld, unless otherwise specified.
    g. At all above grade terminations, the conductors shall be labeled per Specification Section 10 14 00.
3. Ground ring grounding system:
    a. Ground ring consists of ground rods and a conductor looped around the structure.
    b. Placed at a minimum of 2 FT-6 IN below grade.
    c. Building/Structure grounding:
        1) Bond building/structure metal support columns to the ground ring at all corners of the structure.
    d. Grounding conductor: Bare conductor, size as indicated on the Drawings.

C. Supplemental Grounding Electrode:
1. Provide the following grounding in addition to the equipment ground conductor supplied with the feeder conductors whether or not shown on the Drawings.
    a. See Grounding Electrode System paragraph for conductor termination requirements.
2. Metal light poles:
    a. Connect metal pole and pole base reinforcing steel to a ground rod.
    b. Grounding conductor: Bare #6 AWG minimum.
3. Equipment support rack and pedestals mounted outdoors:
    a. Connect metallic structure to a ground rod.
    b. Grounding conductor: #6 AWG minimum.

D. Raceway Bonding/Grounding:
1. Install all metallic raceway so that it is electrically continuous.

2. Provide an equipment grounding conductor in all raceways with insulation identical to the phase conductors, unless otherwise indicated on the Drawings.
3. NFPA 70 required grounding bushings shall be of the insulating type.
4. Provide double locknuts at all panels.
5. Bond all conduits, at entrance and exit of equipment, to the equipment ground bus or lug.
6. Provide bonding jumpers if conduits are installed in concentric knockouts.
7. Make all metallic raceway fittings and grounding clamps tight to ensure equipment grounding system will operate continuously at ground potential to provide low impedance current path for proper operation of overcurrent devices during possible ground fault conditions.

E. Equipment Grounding:
1. Ground all utilization equipment with an equipment grounding conductor.

F. Manhole and Handhole Grounding:
1. Provide a ground rod and ground bar, when indicated or as needed, in each manhole and handhole with exposed metal parts.
a. Expose a minimum of 4 IN of the rod above the floor for field connections to the rod.
2. Connect all exposed metal parts (e.g., conduits and cable racks) to the ground rod.

3.2 FIELD QUALITY CONTROL

A. Leave grounding system uncovered until observed by Owner.

B. Acceptance testing:
1. See Specification Section 26 08 13.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Conduits.
      b. Conduit fittings.
      c. Conduit supports.
      d. Wireways.
      e. Outlet boxes.
      f. Pull and junction boxes.

B. Related Specification Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical - Basic Requirements.
   2. Section 26 05 43 - Electrical - Exterior Underground.
   3. Section 26 27 26 - Wiring Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Aluminum Association (AA).
   2. American Iron and Steel Institute (AISI).
   3. ASTM International (ASTM):
      a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
      c. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
      c. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
      d. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
      e. TC 14.AG, Aboveground Reinforced Thermosetting Resin Conduit and Fittings.
      f. TC 14.BG, Belowground Reinforced Thermosetting Resin Conduit and Fittings.
   5. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. C80.1, Electric Rigid Steel Conduit (ERSC).
      b. C80.3, Steel Electrical Metallic Tubing (EMT).
      c. C80.5, Electrical Aluminum Rigid Conduit (ERAC).
      d. OS 1, Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   6. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   7. Underwriters Laboratories, Inc. (UL):
      a. 1, Standard for Flexible Metal Conduit.
      b. 6, Electrical Rigid Metal Conduit - Steel.
      c. 50, Enclosures for Electrical Equipment, Non-Environmental Considerations.
      d. 360, Standard for Liquid-Tight Flexible Metal Conduit.
      e. 467, Grounding and Bonding Equipment.
      f. 514A, Metallic Outlet Boxes.

g. 514B, Conduit, Tubing, and Cable Fittings.
h. 651, Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
i. 797, Electrical Metallic Tubing - Steel.
j. 870, Standard for Wireways, Auxiliary Gutters, and Associated Fittings.
k. 1203, Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.
l. 2420, Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
m. 2515, Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.3 SUBMITTALS

A. Shop Drawings:
1. Product technical data:
a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
1) Conduit fittings.
2) Support systems.
b. See Specification Section 26 05 00 for additional requirements.
2. Fabrication and/or layout drawings:
a. Identify dimensional size of pull and junction boxes to be used.

1.4 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Rigid metal conduits and electrical metallic tubing:
a. Allied Tube and Conduit.
b. Western Tube and Conduit Corporation.
c. Wheatland Tube.
d. Patriot Aluminum Products, LLC.
2. PVC coated rigid metal conduits:
a. Ocal by Thomas & Betts.
b. Robroy Industries.
3. Rigid nonmetallic conduit:
a. Prime Conduit.
b. Cantex, Inc.
c. Osburn Associates, Inc.
d. Champion Fiberglass, Inc.
e. United Fiberglass of America, Inc.
4. Flexible conduit:
a. AFC Cable Systems.
b. Anamet, Inc.
c. Electri-Flex Company.
d. International Metal Hose Company.
e. Southwire Company, LLC.
5. Wireway:
a. Hoffman Engineering.
b. Wiegmann by Hubbell.
c. Square D by Schneider Electric.
6. Conduit fittings and accessories:
a. Appleton by Emerson Electric Co.
b. Carlon by Thomas & Betts.

c. Cantex, Inc.
d. Crouse-Hinds by Eaton.
e. Killark by Hubbell.
f. Osburn Associates, Inc.
g. O-Z/Gedney by Emerson Electric Co.
h. Raco by Hubbell.
i. Steel City by Thomas & Betts.
j. Thomas & Betts.

7. Support systems:
   a. Unistrut by Atkore International, Inc.
   b. B-Line by Eaton.
   c. Kindorf by Thomas & Betts.
   d. Minerallac Company.
   e. CADDY by Pentair.
   f. Superstrut by Thomas & Betts.
8. Outlet, pull and junction boxes:
   a. Appleton by Emerson Electric Co.
   b. Crouse-Hinds by Eaton
   c. Killark by Hubbell.
   d. O-Z/Gedney by Emerson Electric Co.
   e. Steel City by Thomas & Betts.
   f. Raco by Hubbell
   g. Bell by Hubbell.
   h. Hoffman Engineering.
   i. Wiegmann by Hubbell.
   j. B-Line by Eaton.
   k. Adalet.
   l. RITTAL North America LLC.
   m. Stahlin by Robroy Enclosures.

2.2 RIGID METAL CONDUITS

A. Rigid Galvanized Steel Conduit (RGS):
   1. Mild steel with continuous welded seam.
   2. Metallic zinc applied by hot-dip galvanizing or electro-galvanizing.
   3. Threads galvanized after cutting.
   4. Internal coating: Baked lacquer, varnish or enamel for a smooth surface.
   5. Standards: NFPA 70 Type RMC, NEMA/ANSI C80.1, UL 6.

B. PVC-Coated Rigid Steel Conduit (PVC-RGS):
   1. Nominal 40 MIL Polyvinyl Chloride Exterior Coating:
      a. Coating: Bonded to hot-dipped galvanized rigid steel conduit conforming to NEMA/ANSI C80.1.
      b. The bond between the PVC coating and the conduit surface: Greater than the tensile strength of the coating.
   2. Nominal 2 mil, minimum, urethane interior coating.
   3. Urethane coating on threads.
   4. Conduit: Epoxy prime coated prior to application of PVC and urethane coatings.
   5. Female Ends:
      a. Have a plastic sleeve extending a minimum of one pipe diameter or 2 IN, whichever is less beyond the opening.
      b. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used with it.
   6. Standards: NFPA 70 Type RMC, NEMA/ANSI C80.1, UL 6, NEMA RN 1.

C. Rigid Aluminum Conduit (RAC):
   1. AA Type 6063 aluminum alloy, T-1 temper.

2. Maximum copper content of 0.10%.
3. Extruded, seamless.
4. Standards: NFPA 70 Type RMC, NEMA/ANSI C80.5, UL 6.

2.3 ELECTRICAL METALLIC TUBING (EMT)

A. Mild steel with continuous welded seam.

B. Metallic zinc applied by hot-dip galvanizing or electro-galvanizing.

C. Internal coating: Baked lacquer, varnish, or enamel for a smooth surface.

D. Standards: NFPA 70 Type EMT, NEMA/ANSI C80.3, UL 797.

2.4 RIGID NONMETALLIC CONDUIT

A. Schedules 40 (PVC-40) and 80 (PVC-80):
1. Polyvinyl-chloride (PVC) plastic compound which includes inert modifiers to improve weatherability and heat distribution.
2. Rated for direct sunlight exposure.
3. Fire retardant and low smoke emission.
4. Shall be suitable for use with 90 DEGC wire and shall be marked "maximum 90 DEGC".
5. Standards: NFPA 70 Type PVC, NEMA TC 2, UL 651.

B. Fiberglass:
1. Epoxy based resin system using an anhydride curing agent.
2. Continuous E-glass roving.
3. Winding angle approximately 54.75 DEG.
4. Smooth internal walls with all fibers imbedded in the epoxy.
5. Above grade rated: Halogen free additive for flame spread and smoke control.
6. Ultraviolet inhibitor: Carbon black.
7. Two-step curing process.
8. Tensile strength: 11,000 PSI per ASTM D2105.
9. Dimensions: Iron Pipe Size (IPS).
10. Wall thickness:
    a. Standard: 3/4 IN to 4 IN nominal size.
    b. Medium: 5 IN to 6 IN nominal size.
    c. Extra Heavy for “bullet proof” and Class 1, Division 2 areas: 3/4 IN to 6 IN nominal size.
11. Integral bell and spigot.
12. Conduits and fittings to be joined with an interference joint and epoxy adhesive creating a concrete and water tight connection.
13. Standard: NFPA 70 Type RTRC, NEMA TC14.AG, NEMA TC14.BG, [NEMA TC.XW,] UL 2420, UL 2415 [, UL 2515A].

2.5 FLEXIBLE CONDUIT

A. Flexible Galvanized Steel Conduit (FLEX):
1. Formed of continuous, spiral wound, hot-dip galvanized steel strip with successive convolutions securely interlocked.
2. Standard: NFPA 70 Type FMC, UL 1.

B. PVC-Coated Flexible Galvanized Steel (liquid-tight) Conduit (FLEX-LT):
1. Core formed of continuous, spiral wound, hot-dip galvanized steel strip with successive convolutions securely interlocked.
2. Extruded PVC outer jacket positively locked to the steel core.
3. Liquid and vaportight.
4. Standard: NFPA 70 Type LFMC, UL 360.

2.6 WIREWAY

A. General:

1. Suitable for lay-in conductors.
2. Designed for continuous grounding.
3. Covers:
   a. Hinged or removable in accessible areas.
   b. Non-removable when passing through partitions.
4. Finish: Rust inhibiting primer and manufacturer's standard paint inside and out except for stainless steel type.
5. Standards: UL 870, NEMA 250.

B. General Purpose (NEMA 1 rated) Wireway:
1. 14 or 16 gage steel without knockouts.
2. Cover: Solid, non-gasketed and held in place by captive screws.

C. Raintight (NEMA 3R) Wiring Trough:
1. 14 or 16 GA galvanized steel without knockouts.
2. Cover: Non-gasketed and held in place by captive screws.

D. Watertight (NEMA 4X rated) Wireway:
1. 14 GA Type 304 or 316 stainless steel bodies and covers without knockouts and 10 GA stainless steel flanges.
2. Cover: Fully gasketed and held in place with captive clamp type latches.
3. Flanges: Fully gasketed and bolted.

E. Dusttight (NEMA 12 rated) Wireway:
1. 14 GA steel bodies and covers without knockouts and 10 GA steel flanges.
2. Cover: Fully gasketed and held in place with captive clamp type latches.
3. Flanges: Fully gasketed and bolted.

2.7 CONDUIT FITTINGS AND ACCESSORIES

A. Fittings for Use with RGS and RAC:
1. General:
   a. In hazardous locations listed for use in Class I, Groups C and D locations.
2. Locknuts:
   a. Threaded steel or malleable iron.
   b. Gasketed or non-gasketed.
   c. Grounding or non-grounding type.
3. Bushings:
   a. Threaded, insulated metallic.
   b. Grounding or non-grounding type.
4. Hubs: Threaded, insulated and gasketed metallic for raintight connection.
5. Couplings:
   a. Threaded straight type: Same material and finish as the conduit with which they are used on.
   b. Threadless type: Gland compression or self-threading type, concrete tight.
6. Unions: Threaded galvanized steel or zinc plated malleable iron.
7. Conduit bodies (ells and tees):
   a. Body: Zinc plated cast iron or cast copper free aluminum with threaded hubs.
   b. Standard and mogul size.
   c. Cover:
      1) Clip-on type with stainless steel screws.
      2) Gasketed or non-gasketed galvanized steel, zinc plated cast iron or cast copper free aluminum.
8. Conduit bodies (round):
   a. Body: Zinc plated cast iron or cast copper free aluminum with threaded hubs.
   b. Cover: Threaded screw on type, gasketed, galvanized steel, zinc plated cast iron or cast copper free aluminum.
9. Sealing fittings:

a. Body: Zinc plated cast iron or cast copper free aluminum with threaded hubs.
b. Standard and mogul size.
c. With or without drain and breather.
d. Fiber and sealing compound: UL listed for use with the sealing fitting.

10. Hazardous location flexible coupling (HAZ-FLEX):
    a. Liquid tight and arc resistant.
    b. Electrically conductive so no bonding jumper is required.
    c. Dry and wet areas:
        1) Bronze braided covering over flexible brass core.
        2) Bronze end fittings.
        3) Zinc-plated steel or malleable iron unions and nipples.
    d. Corrosive areas:
        1) Stainless steel braided covering over flexible stainless steel core.
        2) Stainless steel end fittings.
        3) Aluminum unions and nipples.
11. Service entrance head:
    a. Malleable iron, galvanized steel or copper free aluminum.
    b. Insulated knockout cover for use with a variety of sizes and number of conductors.
12. Expansion couplings:
    a. 2 IN nominal straight-line conduit movement in either direction.
    b. Galvanized steel with insulated bushing.
    c. Gasketed for wet locations.
    d. Internally or externally grounded.
13. Expansion/deflection couplings:
    a. 3/4 IN nominal straight-line conduit movement in either direction.
    b. 30 DEG nominal deflection from the normal in all directions.
    c. Metallic hubs, neoprene outer jacket and stainless steel jacket clamps.
    d. Internally or externally grounded.
    e. Watertight, raintight and concrete tight.
14. Standards: UL 467, UL 514B, UL 1203.

B. Fittings for Use with PVC-RGS:
1. The same material and construction as those fittings listed under paragraph "Fittings for Use with RGS [and IMC] [and RAC]" and coated as defined under paragraph "PVC Coated Rigid Steel Conduit (PVC-RGS)."

C. Fittings for Use with EMT:
1. Connectors:
    a. Straight, angle and offset types furnished with locknuts.
    b. Zinc plated steel.
    c. Insulated gland compression type.
    d. Concrete and raintight.
2. Couplings:
    a. Zinc plated steel.
    b. Gland compression type.
    c. Concrete and raintight.
3. Conduit bodies (ells and tees):
    a. Body: Copper free aluminum with threaded hubs.
    b. Standard and mogul size.
    c. Cover:
        1) Screw down type with steel screws.
        2) Gasketed or non-gasketed galvanized steel or copper free aluminum.
4. Standard: UL 514B.

D. Fittings for Use with FLEX:
1. Connector:
    a. Zinc plated malleable iron.

b. Squeeze or clamp-type.
2. Standard: UL 514B.

E. Fittings for Use with FLEX-LT [and FLEX-NM]:
1. Connector:
a. Straight or angle type.
b. Metal construction, insulated and gasketed.
c. Composed of locknut, grounding ferrule and gland compression nut.
d. Liquid tight.
2. Standards: UL 467, UL 514B.

F. Fittings for Use with Rigid Nonmetallic PVC Conduit:
1. Coupling, adapters and conduit bodies:
a. Same material, thickness, and construction as the conduits with which they are used.
b. Homogeneous plastic free from visible cracks, holes or foreign inclusions.
c. Bore smooth and free of blisters, nicks or other imperfections which could damage the conductor.
2. Solvent cement for welding fittings shall be supplied by the same manufacturer as the conduit and fittings.
3. Standards: ASTM D2564, NEMA TC 3, UL 651, UL 514B.

G. Fittings for Use with Rigid Nonmetallic Fiberglass Conduit:
1. Coupling and adapters shall be of the same material, thickness, and construction as the conduit.
2. Epoxy adhesive for joining conduits and fittings shall be supplied by the same manufacturer as the conduit and fittings and shall provide a concrete and water tight connection.
3. Standard: NFPA 70 Type RTRC, NEMA TC14.AG, NEMA TC14.BG, [NEMA TC.XW] UL 2420, UL 2415 [, UL 2515A].

H. Weather and Corrosion Protection Tape:
1. PVC based tape, 10 mils thick.
2. Protection against moisture, acids, alkalis, salts and sewage and suitable for direct bury.
3. Used with appropriate pipe primer.

2.8 ALL RACEWAY AND FITTINGS

A. Mark Products:
1. Identify the nominal trade size on the product.
2. Stamp with the name or trademark of the manufacturer.

2.9 OUTLET BOXES

A. Metallic Outlet Boxes:
1. Hot-dip galvanized steel.
2. Conduit knockouts and grounding pigtail.
3. Styles:
a. 2 IN x 3 IN rectangle.
b. 4 IN square.
c. 4 IN octagon.
d. Masonry/tile.
4. Accessories:
a. Flat blank cover plates.
b. Barriers.
c. Extension, plaster or tile rings.
d. Box supporting brackets in stud walls.
e. Adjustable bar hangers.
5. Standards: NEMA/ANSI OS 1, UL 514A.

B. Cast Outlet Boxes:
1. Zinc plated cast iron or die-cast copper free aluminum with manufacturer's standard finish.

2. Threaded hubs and grounding screw.
3. Styles:
   a. "FS" or "FD".
   b. "Bell".
   c. Single or multiple gang and tandem.
   d. "EDS" or "EFS" for hazardous locations.
4. Accessories: 40 MIL PVC exterior coating and 2 MIL urethane interior coating.
5. Standards: UL 514A, UL 1203.

C. See Specification Section 26 27 26 for wiring devices, wallplates and coverplates.

2.10 PULL AND JUNCTION BOXES

A. NEMA 1 Rated:
1. Body and cover: 14 GA minimum, galvanized steel or 14 GA minimum, steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
2. With or without concentric knockouts on four sides.
3. Flat cover fastened with screws.

B. NEMA 4 Rated:
1. Body and cover: 14 GA steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
2. Seams continuously welded and ground smooth.
3. No knockouts.
4. External mounting flanges.
5. Hinged or non-hinged cover held closed with stainless steel screws and clamps.
6. Cover with oil resistant gasket.

C. NEMA 4X Rated (metallic):
1. Body and cover: 14 GA Type 304 or 316 stainless steel.
2. Seams continuously welded and ground smooth.
3. No knockouts.
4. External mounting flanges.
5. Hinged door and stainless steel screws and clamps.
6. Door with oil-resistant gasket.

D. NEMA 4X Rated (Nonmetallic):
1. Body and cover: Ultraviolet light protected fiberglass-reinforced polyester boxes.
2. No knockouts.
3. External mounting flanges.
4. Hinged door with quick release latches and padlocking hasp.
5. Door with oil resistant gasket.

E. NEMA 7 and NEMA 9 Rated:
1. Cast gray iron alloy or copper-free aluminum with manufacturer's standard finish.
2. Drilled and tapped openings or tapered threaded hub.
3. Cover bolted-down with stainless steel bolts or threaded cover with neoprene gasket.
4. External mounting flanges.
5. Grounding lug.
6. Accessories: 40 MIL PVC exterior coating and 2 MIL urethane interior coating.

F. NEMA 12 Rated:
1. Body and cover:
   a. 14 GA steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
   b. Type 5052 H-32 aluminum, unpainted.
2. Seams continuously welded and ground smooth.
3. No knockouts.
4. External mounting flanges.

5. Non-hinged cover held closed with captivated cover screws threaded into sealed wells or hinged cover held closed with stainless steel screws and clamps.
6. Flat door with oil resistant gasket.

G. Miscellaneous Accessories:
1. Rigid handles for covers larger than 9 SQFT or heavier than 25 LBS.
2. Split covers when heavier than 25 LBS.
3. Weldnuts for mounting optional panels and terminal kits.
4. Terminal blocks: Screw-post barrier-type, rated 600 volt and 20 ampere minimum.

H. Standards: NEMA 250, UL 50.

2.11 SUPPORT SYSTEMS

A. Multi-conduit Surface or Trapeze Type Support and Pull or Junction Box Supports:
1. Material requirements.
a. Galvanized steel: ASTM A123/A123M or ASTM A153/A153M.
b. Stainless steel: AISI Type 316.
c. PVC coat galvanized steel: ASTM A123/A123M or ASTM A153/A153M and 20 MIL PVC coating.

B. Single Conduit and Outlet Box Support Fasteners:
1. Material requirements:
a. Zinc plated steel.
b. Stainless steel.
c. Malleable iron.
d. PVC coat malleable iron or steel: 20 MIL PVC coating.
e. Steel protected with zinc phosphate and oil finish.

2.12 OPENINGS AND PENETRATIONS IN WALLS AND FLOORS

A. Sleeves, smoke and fire stop fitting through walls and floors:
1. See Specification Section 01 73 20.

PART 3 - EXECUTION

3.1 RACEWAY INSTALLATION - GENERAL

A. Shall be in accordance with the requirements of:
1. NFPA 70.
2. Manufacturer instructions.

B. Size of Raceways:
1. Raceway sizes are shown on the Drawings, if not shown on the Drawings, then size in accordance with NFPA 70.
2. Unless specifically indicated otherwise, the minimum raceway size shall be:
a. Conduit: 3/4 IN.
b. Wireway: 2-1/2 IN x 2-1/2 IN.

C. Field Bending and Cutting of Conduits:
1. Utilize tools and equipment recommended by the manufacturer of the conduit, designed for the purpose and the conduit material to make all field bends and cuts.
2. Do not reduce the internal diameter of the conduit when making conduit bends.
3. Prepare tools and equipment to prevent damage to the PVC coating.
4. Degrease threads after threading and apply a zinc rich paint.
5. Debur interior and exterior after cutting.

D. Male threads of conduit systems shall be coated with an electrically conductive anti-seize compound.

E. The protective coating integrity of conduits, fittings, outlet, pull and junction boxes and accessories shall be maintained.
   1. Repair galvanized components utilizing a zinc rich paint.
   2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
   3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the conduit; or a self-adhesive, highly conformable, cross-linked silicone composition strip, followed by a protective coating of vinyl tape.
      a. Total nominal thickness: 40 MIL.
   4. Repair surfaces which will be inaccessible after installation prior to installation.

F. Remove moisture and debris from conduit before wire is pulled into place.
   1. Pull mandrel with diameter nominally 1/4 IN smaller than the interior of the conduit, to remove obstructions.
   2. Swab conduit by pulling a clean, tight-fitting rag through the conduit.
   3. Tightly plug ends of conduit with tapered wood plugs or plastic inserts until wire is pulled.

G. Only nylon or polyethylene rope shall be used to pull wire and cable in conduit systems.

H. Where portions of a raceway are subject to different temperatures and where condensation is known to be a problem, as in cold storage areas of buildings or where passing from the interior to the exterior of a building, the raceway shall be sealed to prevent circulation of warm air to colder section of the raceway.

I. Fill openings in walls, floors, and ceilings and finish flush with surface.
   1. See Specification Section 01 73 20.

3.2 RACEWAY ROUTING

A. Raceways shall be routed in the field unless otherwise indicated.
   1. Conduit and fittings shall be installed, as required, for a complete system that has a neat appearance and is in compliance with all applicable codes.
   2. Run in straight lines parallel to or at right angles to building lines.
   3. Do not route conduits:
      a. Through areas of high ambient temperature or radiant heat.
      b. In suspended concrete slabs.
      c. In concrete members including slabs, slabs on grade, beams, walls, and columns unless specifically located and detailed on structural Drawings..
   4. Locate sleeves or conduits penetrating floors, walls, and beams so as not to significantly impair the strength of the construction. Do not place conduit penetrations in columns.
   5. Conduit shall not interfere with, or prevent access to, piping, valves, ductwork, or other equipment for operation, maintenance and repair.
   6. Provide pull boxes or conduit bodies as needed so that there is a maximum of 360 DEG of bends in the conduit run or in long straight runs to limit pulling tensions.

B. All conduits within a structure shall be installed exposed except as follows:
   1. As indicated on the Drawings.
   2. Concealed above gypsum wall board or acoustical tile suspended ceilings.
   3. Conduits in architecturally finished areas shall be concealed.

C. Maintain minimum spacing between parallel conduit and piping runs in accordance with the following when the runs are greater than 30 FT:
   1. Between instrumentation and telecommunication: 1 IN.
   2. Between instrumentation and 125 V, 48 V and 24 VDC, 2 IN.
   3. Between instrumentation and 600 V and less AC power or control: 6 IN.
   4. Between instrumentation and greater than 600 VAC power: 12 IN.
   5. Between telecommunication and 125 V, 48 V and 24 VDC, 2 IN.
   6. Between telecommunication and 600 V and less AC power or control: 6 IN.

7. Between telecommunication and greater than 600 VAC power: 12 IN.
8. Between 125 V, 48 V and 24 VDC and 600 V and less AC power or control: 2 IN.
9. Between 125 V, 48 V and 24 VDC and greater than 600 VAC power: 2 IN.
10. Between 600 V and less AC and greater than 600 VAC: 2 IN.
11. Between process, gas, air and water pipes: 6 IN.

D. Conduits shall be installed to eliminate moisture pockets.
   1. Where water cannot drain to openings, provide drain fittings in the low spots of the conduit run.

E. Conduit shall not be routed on the exterior of structures except as specifically indicated on the Drawings.

F. Where sufficient room exists within the housing of roof-mounted equipment, the conduit shall be stubbed up inside the housing.

G. Provide all required openings in walls, floors, and ceilings for conduit penetration.
   1. See Specification Section 01 73 20.

3.3 RACEWAY APPLICATIONS

A. Permitted Raceway Types Per Wire or Cable Types:
   1. Power wire or cables: All raceway types.
   2. Control wire or cables: All raceway types.
   3. Instrumentation cables: Metallic raceway except nonmetallic may be used underground.
   4. Motor leads from a VFD: RGS, RAC or shielded VFD cables in all other raceways.
   5. Telecommunication cables: All raceway types.

B. Permitted Raceway Types Per Area Designations:
   1. Dry areas:
      a. RGS.
      b. RAC.
   2. Wet areas:
      a. RGS.
      b. RAC.
      c. Fiberglass (above grade rated).
   3. Corrosive areas:
      a. PVC-RGS.
      b. RAC.
      c. Fiberglass (above grade rated).
   4. Highly corrosive areas:
      a. PVC-RGS.
      b. PVC-80.
      c. Fiberglass (above grade rated).
   5. NFPA 70 hazardous areas:
      a. RGS.
      b. RAC when required by other area designations.

C. Permitted Raceway Types Per Routing Locations:
   1. In stud framed walls:
      a. EMT.
   2. In concrete block or brick walls:
      a. PVC-40.
   3. Above acoustical tile ceilings:
      a. EMT.
      b. NEMA 1 rated wireway.
   4. Embedded in poured concrete walls and floors:
      a. PVC-40.
      b. Fiberglass (above or below grade rated).

c. Fiberglass (above grade rated) when emerging from concrete into areas designated as wet, corrosive or highly corrosive.
d. PVC-RGS when emerging from concrete into areas designated as wet, corrosive or highly corrosive.

5. Beneath floor slab-on-grade:
   a. PVC-40.
   b. Fiberglass (above or below grade rated).
6. Through floor penetrations, see Specification Section 01 73 20:
   a. Fiberglass (above grade rated) in areas designated as wet, corrosive or highly corrosive.
   b. PVC-RGS in areas designated as wet, corrosive or highly corrosive.
7. Direct buried conduits and ductbanks:
   a. PVC-80.
   b. Fiberglass (above or below grade rated).
   c. 90 DEG elbows for transitions to above grade:
      1) PVC-RGS.
      2) Fiberglass (above grade rated).
   d. Long sweeping bends greater than 15 DEG:
      1) PVC-RGS.
      2) Fiberglass (above or below grade rated).
8. Concrete encased ductbanks:
   a. PVC-40.
   b. PVC-EB.
   c. Fiberglass (above or below grade rated).
   d. 90 degree elbows for transitions to above grade:
      1) PVC-RGS.
      2) Fiberglass (above grade rated).
   e. Long sweeping bends greater than 15 DEG:
      1) RGS for sizes 2 IN and larger.
      2) Fiberglass (above or below grade rated).

D. FLEX conduits shall be installed for connections to light fixtures, HVAC equipment and other similar devices above the ceilings.
   1. The maximum length shall not exceed:
      a. 6 FT to light fixtures.
      b. 3 FT to all other equipment.

E. FLEX-LT [and FLEX-NM] conduits shall be installed as the final conduit connection to light fixtures, dry type transformers, motors, electrically operated valves, instrumentation primary elements, and other electrical equipment that is liable to vibrate.
   1. The maximum length shall not exceed:
      a. 6 FT to light fixtures.
      b. 3 FT to motors.
      c. 2 FT to all other equipment.

F. HAZ-FLEX coupling shall be installed as the final conduit to motors, electrically operated valves, instrumentation primary elements and electrical equipment that is liable to vibrate.
   1. The maximum length shall not exceed:
      a. 3 FT to motors.
      b. 2 FT to all other equipment.

G. NEMA 1 Rated Wireway:
   1. Surface mounted in electrical rooms.
   2. Surface mounted above removable ceilings tiles of an architecturally finished area.

H. NEMA 3R Wiring Trough:
   1. Surface mounted in exterior locations.

I. NEMA 4X Rated Wireway:

1. Surface mounted in areas designated as wet and or corrosive.

J. NEMA 12 Rated Wireway:
   1. Surface mounted in areas designated as dry in architecturally and non-architecturally finished areas.

K. Underground Conduit: See Specification Section 26 05 43.

3.4 CONDUIT FITTINGS AND ACCESSORIES

A. Conduit Seals:
   1. Installed in conduit systems located in hazardous areas as required by the NFPA 70.
   2. Fill plug and drain shall be accessible.
   3. Pour the conduit seals in a two-step process.
      a. Pour the seal and leave cover off.
      b. After seal is dry, inspect for proper sealing, install cover and mark (for example, paint or permanent marker) as complete.

B. Rigid nonmetallic conduit and fittings shall be joined utilizing solvent cement.
   1. Immediately after installation of conduit and fitting, the fitting or conduit shall be rotated 1/4 turn to provide uniform contact.

C. Install Expansion Fittings:
   1. Where conduits are exposed to the sun and conduit run is greater than 200 FT.
   2. Elsewhere as identified on the Drawings.

D. Install Expansion/Deflection Fittings:
   1. Where conduits enter a structure.
      a. Except electrical manholes and handholes.
      b. Except where the ductbank is tied to the structure with rebar.
   2. Where conduits span structural expansions joints.
   3. Elsewhere as identified on the Drawings.

E. Threaded connections shall be made wrench-tight.

F. Conduit joints shall be watertight:
   1. Where subjected to possible submersion.
   2. In areas classified as wet.
   3. Underground.

G. Terminate Conduits:
   1. In metallic outlet boxes:
      a. RGS [and IMC and RAC]:
         1) Conduit hub and locknut.
         2) Insulated bushing and two locknuts.
         3) Use grounding type locknut or bushing when required by NFPA 70.
      b. EMT: Compression type connector and locknut.
   2. In NEMA 1 rated enclosures:
      a. RGS [and IMC and RAC]:
         1) Conduit hub and locknut.
         2) Insulated bushing and two locknuts.
         3) Use grounding type locknut or bushing when required by NFPA 70.
      b. EMT: Compression type connector and locknut.
   3. In NEMA 12 rated enclosures:
      a. Watertight, insulated and gasketed hub and locknut.
      b. Use grounding type locknut or bushing when required by NFPA 70.
   4. In NEMA 4 and NEMA 4X rated enclosures:
      a. Watertight, insulated and gasketed hub and locknut.
   5. In NEMA 7 and NEMA 9 rated enclosures:
      a. Into an integral threaded hub.

6. When stubbed up through the floor into floor mount equipment:
    a. With an insulated grounding bushing on metallic conduits.
    b. With end bells on nonmetallic conduits.

H. Threadless couplings shall only be used to join new conduit to existing conduit when the existing conduit end is not threaded and it is not practical or possible to cut threads on the existing conduit with a pipe threader.

3.5 CONDUIT SUPPORT

A. Permitted multi-conduit surface or trapeze type support system per area designations and conduit types:
    1. Dry or wet and/or hazardous areas:
        a. Galvanized system consisting of: Galvanized steel channels and fittings, nuts and hardware and conduit clamps.
        b. Aluminum system consisting of: Aluminum channels, fittings and conduit clamps with stainless steel nuts and hardware.
    2. Corrosive areas:
        a. Aluminum system consisting of: Aluminum channels, fittings and conduit clamps with stainless steel nuts and hardware.
        b. PVC coated steel system consisting of: PVC coated galvanized steel channels and fittings and conduit clamps with stainless steel nuts and hardware.
    3. Highly corrosive areas:
        a. PVC coated steel system consisting of: PVC coated galvanized steel channels and fittings and conduit clamps with stainless steel nuts and hardware.
        b. Fiberglass system consisting of: Fiberglass channels and fittings, nuts and hardware and conduit clamps.
    4. Conduit type shall be compatible with the support system material.
        a. Galvanized steel system may be used with RGS [and IMC] [and EMT].
        b. Stainless steel system may be used with RGS [and IMC] [and PVC-RGS] [and RAC].
        c. PVC coated galvanized steel system may be used with PVC-RGS [and RAC] [and PVC-40] [and PVC-80] [and Fiberglass].
        d. Aluminum system may be used with RAC [and PVC-RGS].
        e. Fiberglass system may be used with PVC-40 and PVC-80 [and PVC-RGS] [and Fiberglass].

B. Permitted single conduit support fasteners per area designations and conduit types:
    1. Architecturally finished areas:
        a. Material: Zinc plated steel, or steel protected with zinc phosphate and oil finish.
        b. Types of fasteners: Spring type hangers and clips, straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
        c. Provide anti-rattle conduit supports when conduits are routed through metal studs.
    2. Dry or wet and/or hazardous areas:
        a. Material: Zinc plated steel, stainless steel and malleable iron.
        b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
    3. Corrosive areas:
        a. Material: Stainless steel and PVC coat malleable iron or steel.
        b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
    4. Highly corrosive areas:
        a. Material: PVC coat malleable iron or steel.
        b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
    5. Conduit type shall be compatible with the support fastener material.
        a. Zinc plated steel, steel protected with zinc phosphate and oil finish and malleable iron fasteners may be used with RGS [and IMC] [and EMT].

b. Stainless steel system may be used with RGS [and IMC] [and PVC-RGS] and RAC.
c. PVC coated fasteners may be used with PVC-RGS [and RAC] [and PVC-40] [and PVC-80].
d. Nonmetallic fasteners may be used with PVC-40, PVC-80 and fiberglass.

C. Conduit Support General Requirements:
1. Maximum spacing between conduit supports per NFPA 70.
2. Support conduit from the building structure.
3. Do not support conduit from process, gas, air or water piping; or from other conduits.
4. Provide hangers and brackets to limit the maximum uniform load on a single support to 25 LBS or to the maximum uniform load recommended by the manufacturer if the support is rated less than 25 LBS.
a. Do not exceed maximum concentrated load recommended by the manufacturer on any support.
b. Conduit hangers:
1) Continuous threaded rods combined with struts or conduit clamps: Do not use perforated strap hangers and iron bailing wire.
c. Do not use suspended ceiling support systems to support raceways.
d. Hangers in metal roof decks:
1) Utilize fender washers.
2) Not extend above top of ribs.
3) Not interfere with vapor barrier, insulation, or roofing.
5. Conduit support system fasteners:
a. Use sleeve-type expansion anchors as fasteners in masonry wall construction.
b. Do not use concrete nails and powder-driven fasteners.

3.6 OUTLET, PULL AND JUNCTION BOX INSTALLATION

A. General:
1. Install products in accordance with manufacturer's instructions.
2. See Specification Section 26 05 00 and the Drawings for area classifications.
3. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
4. Size boxes to accommodate quantity of conductors enclosed and quantity of conduits connected to the box.

B. Outlet Boxes:
1. Permitted uses of metallic outlet boxes:
a. Housing of wiring devices:
1) Recessed in all stud framed walls and ceilings.
2) Recessed in poured concrete, concrete block and brick walls of architecturally finished areas and exterior building walls.
b. Pull or junction box:
1) Above gypsum wall board or acoustical tile ceilings.
2) Above 10 FT in an architecturally finished area where there is no ceiling.
2. Permitted uses of cast outlet boxes:
a. Housing of wiring devices surface mounted in non-architecturally finished dry, wet, corrosive, highly corrosive and hazardous areas.
b. Pull and junction box surface mounted in non-architecturally finished dry, wet, corrosive and highly corrosive areas.
3. Mount device outlet boxes where indicated on the Drawings and at heights as scheduled in Specification Section 26 05 00.
4. Set device outlet boxes plumb and vertical to the floor.
5. Outlet boxes recessed in walls:
a. Install with appropriate stud wall support brackets or adjustable bar hangers so that they are flush with the face of the wall.
b. Locate in ungrouted cell of concrete block with bottom edge of box flush with bottom edge of block and flush with the face of the block.

6. Place barriers between switches in boxes with 277 V switches on opposite phases.
7. Back-to-back are not permitted.
8. When an outlet box is connected to a PVC coated conduit, the box shall also be PVC coated.

C. Pull and Junction Boxes:
   1. Install pull or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.
      a. Make covers of boxes accessible.
   2. Permitted uses of NEMA 1 enclosure:
      a. Pull or junction box surface mounted above removable ceiling tiles of an architecturally finished area.
   3. Permitted uses of NEMA 4 enclosure:
      a. Pull or junction box surface mounted in areas designated as wet.
   4. Permitted uses of NEMA 4X metallic enclosure:
      a. Pull or junction box surface mounted in areas designated as wet and/or corrosive.
   5. Permitted uses of NEMA 7 enclosure:
      a. Pull or junction box surface mounted in areas designated as Class I hazardous.
         1) Provide PVC coating in corrosive and highly corrosive areas when PVC coated conduit is used.
   6. Permitted uses of NEMA 12 enclosure:
      a. Pull or junction box surface mounted in areas designated as dry.

END OF SECTION

DIVISION 33

UTILITIES

SECTION 33 71 16.23
TUBULAR STEEL POLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Technical requirements for the [weathering] tubular steel pole structures, complete with as-specified mounting brackets, tubular steel davit arms, structure erection hardware, pole top caps, bearing plates, base plates, anchor bolt assemblies, and grounding appurtenances as required for each structure.

B. Related Sections include but are not necessarily limited to:

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Supplier Qualifications:
   1. The Supplier should have a registered ISO 9001 quality management system. The registration certificate and the quality manual shall be provided by the Supplier upon request.
   2. In lieu of a registered quality management system, the Supplier shall have a functional quality program in place. The quality manual will be provided upon request. The quality program may be evaluated by the Owner or Owner's Engineer, as part of the Supplier approval process and at any time during the contract.
   3. The Supplier shall submit a quality plan as soon as possible after approval of the contract, but no later than 1 week prior to production start. After the quality plan is submitted, any revisions to the plan shall be communicated to the Owner or Owner's Engineer immediately.

B. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. 318, Building Code Requirements for Reinforced Concrete.
   2. American Institute of Steel Construction (AISC):
      a. 360, Specification for Structural Steel Buildings.
   3. American Society of Civil Engineers (ASCE):
      a. 48, Design of Steel Transmission Pole Structures.
      b. MOP 74, Guidelines for Electrical Transmission Line Structural Loading.
      c. MOP 91, Design of Guyed Electrical Transmission Structures.
   4. American Welding Society (AWS):
      a. D1.1, Structural Welding Code - Steel.
   5. ASTM International (ASTM):
      a. A6/A6M, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
      b. A36/A36M, Standard Specification for Carbon Structural Steel.
      c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      d. A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
      e. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
      f. A354, Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners.
      g. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

h. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
i. A394, Standard Specification for Steel Transmission Tower Bolts, Zinc-Coated and Bare.
j. A500/500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
k. A563, Standard Specification for Carbon and Alloy Steel Nuts.
l. A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
m. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 KSI (345 MPa) Minimum Yield Point, with Atmospheric Corrosion Resistance.
n. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
o. A633/A633M, Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates.
p. A673/A673M. Standard Specification for Sampling Procedure for Impact Testing of Structural Steel.
q. A871/A871M, Standard Specification for High-Strength Low-Alloy Structural Steel Plate with Atmospheric Corrosion Resistance.
r. A992/A992M, Standard Specification for Structural Steel Shapes.
s. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
t. F3125/F3125M, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 KSI (830 MPa) and 150 KSI (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

6. Institute of Electrical and Electronics Engineers (IEEE):
   a. C2, National Electrical Safety Code (NESC).
7. International Organization for Standardization (ISO):
   a. 9001, Quality Management Systems — Requirements.
8. Steel Structures Painting Council (SSPC):
   a. SP1, Solvent Cleaning
   b. SP6, Commercial Blast Cleaning.
   c. SP7, Brush-Off Blast Cleaning.
   d. SP10, Near-White Blast Cleaning.

1.3 DEFINITIONS

A. Cambering: Fabricating of a slight convex curve in a pole or cross-arm.

B. d/t: Ratio of the diameter of a tubular pole to the steel plate thickness.

C. Contractor: The line construction company, and their authorized representatives, typically contracted for by the Owner, responsible for erecting the steel pole structure, with all appurtenances. The Contractor may also be internal construction staff employed under the direct supervision of the Owner.

D. Engineer: A registered or licensed person who may be a staff employee or an outside consultant, who provides engineering services for the Owner. Engineer also includes duly authorized assistants and representatives of the licensed person.

E. Ground line: A designated location on the pole where the surface of the ground will be after installation of a direct embedded pole.

F. Overload capacity factors (OCF): Multipliers that are applied to each of the vertical, transverse, and longitudinal structure loads to obtain an ultimate load.

G. Owner: As used in this specification, shall refer to the purchaser and/or user of the material, or its agents.

H. P-delta moment: Secondary moment created by the vertical loads acting on the structure when the structure deflects from its unloaded position.

I. Point of fixity: Location on the pole at the ground line or below the ground line where the maximum moment occurs.

J. Project: The line within which the steel pole will be used. Typically, the "Project" will be referred to as a proposed or existing high voltage transmission line, but may also only include a single pole replacement or addition.

K. Raking: The practice of erecting a straight pole out of plumb, or at an inclined angle. "Raking" of a pole is usually done to oppose the direction of the resultant vector sum load under that stated load case.

L. Supplier: The pole manufacturer, who is responsible for the design of the pole and all included appurtenances, fabrication and finishing, adherence to both project specifications and industry practices, and delivery of the pole. The "Supplier" may also include their engineer, or other authorized representative, to respond to questions or other technical or fabrication issues as they may arise.

M. Ultimate load: Maximum design load, which includes the appropriate overload capacity factors.

N. w/t: Ratio of the width of the pole (flat-to-flat) to the plate thickness.

1.4 SUBMITTALS

A. Design Calculations:
   1. Documentation to be supplied for the Owner's and Owner's Engineer approval prior to fabrication includes final design calculations for pole shaft, base plate, anchor bolts, and arms, including their connections.
      a. For the loading cases with overload factors, the total shear, axial forces, moments stresses or stress ratios, section moduli, cross-sectional areas, deflections w/t's for polygonal d/t's for round cross sections at all splices, at arm attachment points (top and bottom), and at least every 10 FT along the pole.
      b. For the critical loading case, shear and axial forces, moments, stresses, section moduli, cross-sectional areas at the arm connections, bolt stresses in the arm connection, and deflection at the end of the arm.
      c. Anticipated deflections at the top of the pole and at the ends of the arms shall be indicated for each pole for the deflection case specified on the design drawings.
      d. For all specified loading cases, reactions and ground line moments shall be supplied.
      e. Calculated shipping weight of each structure excluding anchor bolts. Separate weights shall be given for arms and poles.
      f. Ultimate groundline reactions (including overload factors) in poles and guy wires.
      g. Description of pole shaft, including thickness, length, diameter, cross-sectional geometry, and method of fastening each shaft component.
      h. Data showing the design of the arm, arm connections, arm attachment plates and brackets.

B. Shop Drawings:
   1. The standard drawing size for shop drawings shall be 22 IN by 34 IN (ANSI D), but the drawings should be prepared in order that they can be reprinted/copied and reviewed as 11 IN by 17 IN plots. Drawings shall be laid out in legible, organized manner, with uniformity in appearance, style, contents, and dimensional proportions. Material lists shall be included on the shop drawings.
   2. Provide two sets of hard copy drawings and two sets in electronic (pdf) format prior to fabrication. Shop drawings submittals shall be sent directly to the Owner and the Engineer, with the Owner receiving one hard copy set and one electronic set and the Engineer receiving one hard copy set and one electronic set.

3. The Engineer will return to the Supplier, within two weeks after receipt, one set of drawings marked "Revise & Resubmit," "Furnish as Submitted," "Furnish as Noted," "Not Reviewed," or "Rejected," as the case may be. For any resubmittal, all revisions will be clearly shown on the resubmitted sets of drawings. Design revisions, in accordance with corrections shown thereon, may be considered as ready for fabrication. Corrections or revisions shown on "Resubmit" set shall be made. Drawings shall be returned two weeks after notice of requiring resubmittal.
4. After approvals are received and shop drawings finalized, the Supplier shall furnish two hard copy sets and two electronic (pdf) sets of structural steel shop drawings with the Owner receiving one hard copy set and one electronic set and the Engineer receiving one hard copy set and one electronic set. The drawings will be used for construction purposes.

C. Product Data:
1. Acknowledgement that products submitted meet requirements of standards referenced.
   a. Type of material of major components.
2. Certifications (upon request).
   a. Certified Material Test Reports (CMTR) shall be submitted to the Owner at no cost.
   b. Certified welding reports for each structure.
   c. Incoming, in-process and final quality records.
3. Test reports:
   a. Anchor bolts, structural plate, and weld material, shall meet the following requirements for Charpy V-notch tests:
      1) The impact properties in the longitudinal direction of the material, for base plates, shafts, attachment lugs and flanges shall be a minimum of 20 Joules (15 FT-LB) for the average of the three specimens and no single specimen shall be less than 16 Joules (12 FT-LB). The test temperature shall be -20 DEGC and testing shall in accordance with ASTM A673.
      2) For plates 1/2 IN or less in thickness and for quenched and tempered or normalized plates of any thickness, heat lot testing may be used to determine whether the material meets the impact property requirements.
      3) Controlled rolled or as-rolled plates and shapes over 1/2 IN in thickness shall be tested on a slab (plate) testing basis.
      4) Anchor bolts shall have minimum Charpy V-notch impact properties in the longitudinal direction of 20 Joules (15 FT-LB) for the average of the three specimens and no single specimen shall be less than 16 Joules (12 FT-LB). The test temperature shall be -20 DEGC and testing shall be in accordance with ASTM A673.
   b. Test reports on coating thickness.
   c. Report of structure testing, when required, including photographs, diagrams, load trees, test equipment calibration records, etc.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials shall comply with the applicable requirements of IEEE/NESC and ASTM specifications. Any modifications to the specifications must be approved by the Owner or its representative prior to bidding.

B. All steel shall conform to ASTM A6/A6M.

C. Poles, arms and conductor brackets shall conform to ASTM A572, ASTM A588, and ASTM A871 with a minimum yield strength of 50 KSI.

D. Base plate shall conform to ASTM A572, ASTM A588, ASTM A633, or ASTM A871 with a minimum yield strength of 50 KSI.

E. Other structural steel shall conform to ASTM A500 Grade B (HSS), ASTM A36 (miscellaneous shapes and bars), or ASTM A992 (wide flange).

F. For galvanized structures, all steel used shall have a silicon content less than 0.06%.

G. All structural bolts shall conform, as applicable, to ASTM F3125 Grade A325, ASTM A354, or ASTM A394. Nuts shall conform to ASTM A563, Grade DH. American Nut Company (ANCO) type self-locking nuts shall be provided for each structure bolt.

H. Anchor bolts for self-supporting structures shall be as required by structure design and anchor bolt material shall conform to ASTM, A615 Grade 60, or Grade 75. Each anchor bolt shall be furnished with two nuts (one below the base plate for leveling and one above for securing the pole with base plate to the anchor bolt) and two flat washers.

2.2 DESIGN CRITERIA

A. The design, fabrication, allowable stresses, processes, tolerances, and inspection shall conform to the American Society of Civil Engineers (ASCE) Standard 48, latest edition.

B. Pole structures shall consist of constant tapered regular polygonal tube sections with a minimum of 12 sides. The pole diameter measured shall be measured across flats.

C. Structure beams shall be either multi-sided tube sections or standard hollow structural sections (HSS) as listed in AISC 360.

D. Circular or polygonal cross sections for welded steel tubular members are preferred.

E. Pole tube sections shall have nearly uniform taper, and shall be required to be within [0.15 to 0.5] IN per linear foot, unless otherwise approved by the Engineer.

F. Minimum plate thickness for all pole components shall be 3/16 IN.

G. Pole designs shall be prepared from the provided configuration Drawings and design loads. The structure shall be capable of withstanding all specified loading cases including secondary stresses from foundation movements (when foundation movements are specified), and from vertical loads acting on lateral pole deflection (P-delta effect). Design of poles for these secondary stresses shall not consider the possible restraining effect of conductors or shield wires. The structure shall withstand the loads without failure, permanent distortion, or exceeding any specified deflection limitations. Longitudinal loads specified on the supplied Drawings shall not be reduced due to the flexibility of the structure. Arm designs and base plate designs shall be supported by actual test results.

H. All loads shown in the load and design Drawings include the appropriate overload factors as per NESC Table 253-1 [2012 or 2017 Edition]. All load cases are to be considered as shown in the Drawings.

I. Wind pressures shown in the loading criteria shall be multiplied by the appropriate shape factor applied to the poles. Pressures, in Pa, shall be computed as follows:

p = W x Cd
p = pressure on projected area of the pole normal to wind
W = wind pressure
Cd = shape (or drag) factor

Shape factors for computing the wind on poles are:

J. Designs, in addition to the loading conditions to be considered in the Drawings, shall accommodate load allowances for handling, transportation, and erection without failure, permanent deformation, or damage to the pole when handled according to the Suppliers instructions. Furthermore, the structural design shall accommodate an atmospheric temperature range of -40 DEGF to 120 DEGF.

K. Attachment details for overhead ground wires (OHGW) and conductors are shown on the load and design Drawings. Standard pole line hardware will be used for all attachments and will be the responsibility of the Owner.

L. Deflection Limitations:
   1. Terminal Deadend Structures:
      a. Horizontal deflection of vertical members:
         1) For 40 DEGF, 2 PSF wind, initial tension conditions load case: The greater of 1 PCT of above ground pole length, or 40% of the pole base diameter.
      b. Combined vertical and horizontal deflection of horizontal members.
         1) For 40 DEGF, 2 PSF wind, initial tension condition load case: 0.5% of unsupported arm length.
         2) For all other listed load cases: 6 IN maximum combined (vector sum) deflection.
   2. Suspension, Angle, and In-Line Deadend Structures:
      a. Horizontal deflection of vertical members:
         1) For 40 DEGF, 2 PSF wind, initial tension conditions load case: The greater of 1 PCT of above ground pole length, or 40% of the pole base diameter.
      b. Combined vertical and horizontal deflection of horizontal members:
         1) For 40 DEGF, 2 PSF wind, initial tension condition load case: 0.5% of unsupported arm length.
         2) For all other listed load cases: 6 IN maximum combined (vector sum) deflection.
   3. Switch Structures:
      a. Horizontal deflection of vertical members:
         1) For 40 DEGF, 2 PSF wind, initial tension conditions load case: The lesser of 0.5 PCT from tip of structure to switchgear handle, or 40% of the pole base diameter.
      b. Combined vertical and horizontal deflection of horizontal members:
         1) For 40 DEGF, 2 PSF wind, initial tension condition load case: 0.5% of unsupported arm length.
         2) For all other listed load cases: 3 IN maximum combined (vector sum) deflection.

M. The maximum design unit stress shall be the minimum yield strength as stated in applicable ASTM and IEEE/NESC specifications for the particular application and types of loads, including overload factors.

N. Foundation rotation and deflection shall be included at the pole base for worst case line loading(s) and considered when determining the appropriate pole shaft sizes, base plates, anchor bolts, connections, and other structural members that would be impacted by displacement at the pole base. The permanent (non-recoverable) foundation rotation and deflection limits are as follows:
   1. For permanent rotation: 1.5 DEG – to be applied to the worst case loading(s) and the vector sum of rotation shall be approximated based on the loads acting in the transverse and longitudinal directions for those load case(s).
   2. For permanent vertical settlement: 3 IN – to be applied to the worst case loading(s).
   3. For permanent horizontal deflection: 3 IN – to be applied to the worst case loadings.
   4. Maximum allowed rotation and deflection limits, to be applied at the top of the pier (base of the pole) and evaluated as part of the foundation design, are:
      a. 2 DEG rotation.
      b. 4.5 IN vertical settlement.
      c. 4.0 IN horizontal displacement.

O. The ultimate load in guys shall not exceed [65]% of the rated breaking strength of the guy. The Supplier shall advise the Owner if the specified guy wire size is inappropriate prior to submitting a bid.

P. Joints:
   1. Poles shall be designed with a minimum number of joints. Field welding shall not be allowed as part of the design of a new pole. The shaft joints to be made in the field shall be slip joints or bolted flange joints.
   2. Slip joint length shall be a minimum of 1.5 times the largest inside diameter of the female section. Supplier shall verify slip joint fit prior to shipment.
   3. Slip joints shall be designed in accordance with requirements provided in ASCE/SEI Standard 48. Slip joints shall only be used if the jacking force exceeds the maximum design compressive force. Slip joints are not recommended for use in guyed deadend structures or those subjected to uplift forces. Sufficient jacking lugs shall be provided at each slip joint and shall be placed so as to not interfere with maximum overlap on the joint, grounding pads, ladder clips, or other details.
   4. Slip joints are not permitted within the supply space of transmission phases. Slip joints may be allowed between the transmission and an under-build circuit so long as the required separation values are maintained.
   5. Flange plate connections shall be used for guyed deadend, h-frame, and switch structures and shall be designed in accordance with requirements provided in ASCE/SEI Standard 48. Flexural stress in the flange plate shall not exceed the specified minimum yield stress of the plate material, and the flange plate connections shall be designed to resist the maximum forces and moments at the connection. As a minimum, the flange plate connection shall also be designed to resist 50% of the moment capacity of the lowest strength adjoining tube. The Supplier shall verify upper to lower flange plate fit and connectivity prior to shipment.

Q. Supplier shall provide cap plate at pole top. The cap plate shall be no more than 2 IN larger than the pole top diameter. The plate shall not be vented but fitted flush and seal welded to the top of the pole.

R. Arms:
   1. Arms shall be designed so the end of the arm is at the specified height under the deflection loading case shown on the Drawings.
   2. Arms shall not deflect vertically more than 12 IN at the end of the arm under any loading condition.
   3. Arms shall be upswept or straight, tapered, steel tubular members, of any cross-sectional type, which meet the dimensions shown on the supplied Drawings.
   4. Arm end plate connection details for hardware attachment shall be typical of those shown on the provided configuration Drawings.
   5. The arms shall be hermetically sealed if a painted finish or weathering steel is specified.
   6. Galvanized arms shall have drain holes where appropriate.
   7. Arms and arm attachments shall be designed to avoid trapping or holding moisture.
   8. For davit arms the horizontal offset listed on the load and design Drawings shall be measured from pole face.
   9. If longer than 4 FT, davit arms shall be upswept unless otherwise noted. The arms can be either linear or curved profiles and manufactured as multi-sided or round tubes.
   10. See Drawings for details of arm attachment and vangs. Supplier will provide all necessary arm bracket vangs and hardware to attach the arm.
   11. Davit arm thru vangs and base connections shall be a minimum of 1 IN thick.
   12. Arms shall have hand holds/climbing loops provided as detailed on the Drawings.
   13. Hand holds/climbing loop shall have a 500 LB vertical capacity.

S. Anchor Bolts:
   1. Supplier will furnish structures with base plates, templates, and threaded anchor bolts with two heavy hex nuts and two flat washers. Either the Contractor or the Supplier will assemble the anchor bolts into a cage.

2. Minimum anchor bolt projection out of the top of the concrete shall be 12 IN.
3. Anchor bolts shall be threaded at the top end a minimum of 12 IN.
4. The anchor bolt cage shall include upper and lower steel templates which shall be fabricated within a tolerance of 1/16 IN.
5. The top 2 FT of all anchor bolts shall be galvanized.
6. The anchor bolts are not expected to be full-length unless specified on the Drawings. Minimum embedment lengths will be determined using the ultimate bond stress values as listed in the latest addition of ACI 318.
7. For bond stress calculations, concrete compressive strength shall be assumed to be 3000 PSI in 28 days.
8. The anchor bolt threads shall be protected during shipping. The anchor bolts shall be welded to the holding plate in the bottom of the cage if shipped assembled. The top template shall be designed to be removable and to support the assembled cage during lifting and setting operations without detrimental deformations. Bolt clusters shall be designed to be rigid enough to withstand the normal jolts of shipping, handling and installation with no displacement of bolts from the proper positions within the cluster.
9. Welding on anchor bolts will only be allowed in the bottom 1 FT.
10. Only one length of anchor bolt shall be used on each pole.
11. Anchor bolts/clusters shall be plainly marked to indicate the structure type, structure number, orientation, and top of concrete.
12. Supplier shall refer to the Project(s) Bid Unit Form, included as an attachment to this specification, for providing pricing for the following delivery options:
    a. Fully assembled in a single cage, or.
    b. Packaged securely together, with templates, but unassembled.
13. The removable template at the top of the anchor bolt assembly shall be marked with a v-notch to show the angle bisector (transverse axis as shown on Drawings) for all structures. Two, 0.5 IN diameter holes shall be drilled in the template at locations 90 DEG to bisector.
14. Template shall be a minimum thickness of 0.5 IN.

T. Direct Embed Structures:
1. Structures which are to be direct embedded shall have bearing plates and ground sleeves. Bearing plates shall have a diameter not more than [2] IN greater than the maximum pole diameter.
2. Structures shall have a ground sleeve. Ground sleeves shall have a minimum length of [3 FT, extending 2 FT below ground line and 1 FT above]. The minimum thickness shall be 3/16 IN. A seal weld shall be provided around the ground sleeve (top and bottom). The ground sleeve shall not be considered in the strength calculations for the steel pole.

U. Lifting Lugs and Attachments:
1. Lifting lugs shall be provided on large pole sections as required, the Supplier is to determine this. The lugs shall be designed and positioned such that the pole section will hang nearly vertical when suspended from the lugs. Lifting lugs on arms are optional. The Supplier shall supply complete instructions for handling and erection of poles and arms.
2. In the design of connections for vangs, brackets, or stiffeners attached to the pole shaft, care shall be taken to distribute the loads sufficiently to protect the wall of the pole from local buckling.

V. Climbing Devices:
1. Clips for working/climbing ladders are to be included on one flat the entire length of each pole beginning 10 FT from the designated pole ground line or base plate, and in all four quadrants 5 FT below each wire attachment point.
2. Ladders shall be “McGregor” type or equivalent.
3. Each ladder clip shall be designed to support a minimum 1000 LB vertical load and a minimum 200 LB horizontal working load.
4. The clips shall be welded to the pole surface.
5. Ladder clips shall be located to avoid interference between ladders and other attachments.

6. Ladder clips shall provide maximum safety, minimum projection beyond the shaft surface, minimum opportunity for corrosion, and shall not permit air to enter the shaft.

W. Grounding Devices:
   1. A NEMA-drilled two-hole pad shall be welded to the pole at locations shown on the drawings for grounding purposes.
   2. Multi-piece structures shall have two-hole NEMA grounding pads located on both sides of each structure joint, 11 IN from the assembled joint surface (22 IN maximum between NEMA pads).
   3. Grounding pad face shall not be painted or covered with other coatings.
   4. The grounding pad threads shall be protected from coatings.
   5. Personal Ground shall be provided 6 IN below each conductor attachment. Personal ground shall be a 0.75 IN DIA, stainless-steel rod. Ground shall be 1 FT long and project from the pole surface 4 IN.

X. Moisture Prevention:
   1. Galvanized poles shall have a drain hole at the bottom. When a painted finish is specified, poles shall be hermetically sealed.
   2. Structures shall be designed to eliminate water and refuse traps.
   3. Factory drilled pole holes shall be plugged to prevent moisture intrusion during shipping.
   4. For field drilled poles and factory drilled poles, Supplier shall provide silicon sealant to seal all through-bolt holes.
   5. Structures, when assembled, shall be effectively sealed to prevent moisture intrusion.
   6. Connections shall be designed to reduce the effect of pack-out by preventing moisture from entering the joint or by designing the connection to allow moisture to easily drain off.
   7. Plastic plugs shall be installed in all nuts welded to the structure and all tapped holes.

PART 3 - EXECUTION

3.1 FABRICATION

A. Steel pole structures shall be fabricated as shown on the load and design drawings. Supplier shall assume responsibility as noted. Supplier shall verify all dimensions to verify proper fit up of structure connections prior to fabrication. Any deviation in dimension or materials from that shown on the drawings shall be submitted to the Engineer for written approval prior to fabrication. Such submittals shall be in the form of shop fabrication drawings, per Section 1.4 of this Specification.

B. Prior to being worked in any manner, structural materials shall be cleaned of all rust and foreign particles.

C. Material shall be straight within the tolerance allowed by ASTM A6. If straightening is necessary, it may be done by mechanical means or by application of a limited amount of localized heat. Straightening shall be done in a manner that will not injure the material.

D. All forming or bending during fabrication shall be done by methods that will prevent embrittlement or loss of strength in the material being worked.

E. All formed sections shall have a minimum bend radius in accordance with the Bend Test Requirements as outlined in the ASTM standards.

F. Poles shall have a nearly uniform taper throughout their entire length. The maximum difference in tapers between two pole sections measured by the diameters shall be 0.2 IN/FT for poles with variable taper.

G. Pole height shall be the height of the pole from the top of the baseplate, or designated ground line, to the top of the structure.

H. Shearing and cutting shall be performed carefully and all portions of the work shall be finished neatly. Copes and re-entrant cuts shall be filleted before cutting.

I. Punching and drilling shall be done accurately. Center to center distance between holes of a piece shall not vary more than 1/16 IN from the specified dimension. Holes other than those shown on the drawings shall be approved by the Engineer. Burrs caused by drilling or punching shall be removed.

J. Holes for connection bolts shall be 1/16 IN larger than the nominal diameter of the bolts.

K. Holes in the flange plates for bolted splices shall be 1/8 IN larger than the bolt diameter.

L. Holes in the base plates for anchor bolts shall be 3/8 IN larger than the nominal diameter of the anchor bolts.

M. Holes of any diameter may be drilled in plate of any thickness. Care shall be taken to maintain accuracy when drilling stacks of plates.

N. Holes may be made by use of a machine guided oxygen torch. Flame cut edges shall be reasonably smooth and suitable for the stresses transmitted to them.

O. All holes, blocks, and clips shall be made with sharp tools and shall be clean-cut without torn or ragged edges.

P. Holes in vangs shall be chamfered 1/8 IN.

Q. Punched Holes:
   1. Holes shall be true to size, smooth and cylindrical without excessive tear-out or depressions.
   2. Burrs that remain after punching shall be removed by grinding, reaming, etc.
   3. Holes shall not be punched in material thicker than 0.75 IN.

R. All connections shall be shop welded, except as noted below:
   1. Connections required or provided for disassembly and shipment of structure. Field welding for reassembly will not be permitted.
   2. Bolted connections shown on the specification drawings or approved on the Supplier's shop drawings.

S. Welding:
   1. All welding shall be in accordance with the requirements of the AWS D1.1.
   2. Welding electrodes shall be heated E-70XX or equivalent wire if semi-automatic or automatic welding is used.
   3. Welding shall be performed by operators who have been qualified by tests as prescribed by AWS D1.1 to perform the type of welding required.
   4. One hundred percent (100%) weld penetration shall be required but not limited to the following areas:
      a. Circumference welds joining structural members.
      b. Longitudinal welds in female portion of slip joint.
      c. Welds at butt joints of back-up strips.
      d. Base plate to shaft welds.
      e. Longitudinal welds adjacent and within 3 IN of circumference welds, flange welds, base welds and ends of tube.
   5. Full penetration or equivalent 90% partial penetration welds with fillet overlay shall be used for arm-to-arm base, vang-to-plate shaft, and arm box joints.
   6. All other penetration welds shall have 60% minimum penetration.
   7. All weld back-up strips shall be continuous the full length of the welds. Care shall be exercised in the design of welded connections to avoid areas of high stress concentration which could be subject to fatigue or brittle fractures.
   8. Welds shall be free of any cracking, either surface or subsurface.
   9. No undercutting of steel is allowed.
   10. Welds shall be free of surface blowholes, flow holes, and spherical inclusions.
   11. Field welding shall not be permitted except with Owner's approval and the Supplier's direction in repairing a pole.

T. The overall length of the assembled structure should not be less than 6 IN of the specified length and not more than one foot.

U. Finish:
1. Galvanized Steel:
   a. All steel components which are hot-dip galvanized shall meet all the requirements of ASTM A123 or ASTM A153.
   b. Measures shall be taken to prevent warping and distortion according the ASTM A384 and to prevent embrittlement according to ASTM A143.
   c. Remove all flux from welds and remove all sharp edges and burrs prior to finishing.
   d. Fabrication shall be complete prior to finishing.
      1) No bending, working, or machining shall take place after galvanizing unless assembly is too large to permit. In such cases, sections shall be galvanized, then welded, then weld metalized.
      2) If metalizing is required due to size, metalizing shall overlap galvanizing a minimum of 2 IN.
      3) Metalizing shall have a minimum thickness of 5 MILS.
   e. Minimum weight of zinc specified shall be per ASTM standard.
   f. Bolts and nuts with yield strengths less than 100,000 PSI shall be hot-dip galvanized per ASTM A153 and ASTM A143 or mechanically coated with zinc in accordance with ASTM B695, Class 55.
   g. Bolts and nuts with yield strengths in excess of 100,000 PSI shall not be hot-dip galvanized. They shall be painted with zinc enriched paint or mechanically coated with zinc in accordance with ASTM B695, Class 55.
2. Weathering Steel:
   a. All steel components shall conform to ASTM A588 or A871.
   b. After fabrication the poles shall be cleaned of oil, dust, grease, dirt, and any other foreign material (SSPC-SP1).
   c. After surface cleaning, the steel shall be blast cleaned to remove scale, loose rust etc., in accordance with SSPC-SP6 surface preparation specification; to ensure uniform and rapid formation of the protective oxide layer.
3. Painted Steel:
   a. Galvanized:
      1) Previously galvanized steel substrates shall be cleaned to remove all oil, dust, grease, dirt, and any other foreign material (SSPC-SP1).
      2) After surface cleaning, galvanized substrates shall receive brush blasting to remove 'sheen' and produce a minimum 1.5 MIL profile (SSPC-SP7).
      3) Following surface preparation, coating shall proceed as specified below (3.b.4).
   b. Bare Steel:
      1) Bare steel substrates shall be cleaned to remove all oil, dust, grease, dirt, loose rust and any other foreign material (SSPC-SP1).
      2) After surface cleaning, steel substrates shall receive abrasive blasting to produce a minimum 1.5 MIL profile (SSPC-SP10), or as directed by the selected coating manufacturer's data sheet.
      3) All coating work shall be completed within the same shift as abrasive blasting occurs. Steel surfaces that are not coated within the shift (8 HRS) shall be brush blasted (SSPC-SP7) prior to coating to remove any oxidation, which may have formed.
      4) Select an appropriate coating system, as summarized below, and perform the steel coating following the manufacturer's written instructions (data sheets).

System Number	Substrate	Surface Preparation	Profile (MILS)	Primer/First Coat	Top Coat
1	Galvanized	SSPC-SP1		Carboline Sanitile® 120	Carbocrylic® 3357 HB

System Number	Substrate	Surface Preparation	Profile (MILS)	Primer/First Coat	Top Coat
2		SSPC-SP1, SSPC-SP7	2.0-3.0	Carboline Carbomastic® 15	Carbothane® 134 HB
3		SSPC-SP1		Sherwin-Williams Galvite HS	Corothane® I HS
4*		SSPC-SP1, SSPC-SP7	1.0-2.0	Devoe Devcryl® 1440	Devcryl® 1449
5	Bare Steel	SSPC-SP1, SSPC-SP10	2.0-3.0	Carboline Carbomastic® 15	Carbothane® 134 HB
6		SSPC-SP1, SSPC-SP10	2.0	Sherwin-Williams Steel Spec™ Epoxy Primer	Corothane® I HS
7*		SSPC-SP1, SSPC-SP6	1.5-2.5	Devoe Devcryl® 1440	Devcryl® 1449

*Water-borne coating

4. Direct Embed Steel:
   a. Supplier shall clean all surfaces intended to be coated to remove all oil, dust, grease, dirt, loose rust and any other foreign material to ensure proper adhesion (SSPC-SP1).
   b. Supplier shall blast clean the steel substrate surfaces to be coated with steel grit or sand (steel shot not acceptable) in accordance with the selected coating manufacturer's recommendations. Typically, a minimum SSPC-SP6 surface preparation and a minimum substrate surface profile of 1.5 MILS.
   c. Supplier will apply protective coating to blast cleaned substrate surfaces with one of the following approved coatings (coal tar epoxy, or equivalent):
      1) TARGUARD® (Sherwin Williams).
      2) CorroCote II Classic (Valspar Coatings).
      3) Devtar® 5A (Devoe).
      4) Tneme-Tar® 46H-413 (Tnemec).
      5) Bitumastic® 50 (Carboline).
   d. All below grade surfaces will be coated including the bearing plate and extend to [6] IN above the top of the ground sleeve. Acceptable coating thickness shall be [14-16] MILS dry thickness.
   e. Coatings showing sags, checks, teardrops, or fat edges are not acceptable. Coatings with defects shall be entirely removed and recoated.

3.2 INSPECTION AND TESTING

A. The Owner and its designated agents shall have free entry at all times while work is being carried on, to all parts of the Supplier 's plant to inspect any part of the production of the poles covered by this Specification.

B. Steel members which are bent or warped or otherwise improperly fabricated shall be properly repaired or replaced.

C. The cost of tests made by the Supplier or Manufacturer, including cost of the certified test reports shall be considered and included in the price.

D. The Supplier or Manufacturer shall make tests in accordance with ASTM A370 and ASTM A673 to verify that the material used in the structures meets the impact properties.

E. Mill test reports showing chemical and physical properties of all material furnished under this specification shall be traceable to the structure.

F. All plates over 1-1/2 IN thick shall be ultrasonically tested to ensure against defects which could lead to laminar tearing.

G. All visual and non-destructive inspection will be carried out by qualified testing personnel.

H. Weld Quality & Inspection:
   1. The Supplier or Manufacturer shall make certified welding reports for each structure. The reports covering welding shall include all welds of a structure. Each weld shall be clearly identified and the report shall consist of the method of testing, whether the weld is acceptable, the identification of the structure, the date, and the name and signature of the inspector.
   2. Quality and acceptability of the complete length of all full penetration welds shall be determined by visual and ultrasonic inspection.
   3. Quality and acceptability of all welds other than full penetration welds shall be determined by visual inspection, supplemented by magnetic particle, ultrasonic or dye penetrant inspection.
   4. Records of welding procedure and welding operator test results shall be kept for 6 years by the Supplier and shall be made available for review by the Owner.
   5. Weld quality shall conform to AWS D1.1, regardless of the method of welding.
   6. Visual Inspection: Work shall be examined to determine that it meets the requirements of this specification. The size and contour of welds shall be measured with suitable gauges. All welds shall be visually inspected for cracks and other defects. Magnifiers may be required for clear visibility.
   7. Ultrasonic Inspection: Ultrasonic inspection shall be performed on all full penetration welds in accordance with the requirements of Section 6, Part F of the AWS D1.1.

3.3 FULL-SCALE LOAD TEST

A. Full-scale load tests have to be performed on the structures which are subject to such tests as noted on the Drawings.

B. The load testing of any specific pole shall be on a full-scale basis at the Supplier's facility or at a location as specified by the Owner. Costs for such testing shall be the responsibility of the Owner, shall be separated from the Supplier's bid, and shall be negotiated in advance of any test preparation.

C. Material procurement for test poles shall be identical to material procurement procedures for regular production run poles.

D. The number, location, direction, holding time, sequence, and increments of the test loads along with the number, location, and direction of deflection readings for an individual pole test shall be approved by the Owner prior to pole testing.

E. The method of attaching the test loads to the pole, applying the test loads, measuring and recording the test loads, and measuring and recording the deflections shall be approved by the Owner prior to pole testing.

F. A full report listing results shall be submitted after completion of all testing. Copies of mill test reports shall be included in the load test report. The report shall also include a complete description of the load tests with diagrams and photographs. If required, the Supplier shall provide the Owner with the following testing data:
   1. Location of testing.
   2. Method of full scale testing: upright or horizontal.
   3. The pole tester shall issue the Owner three copies of the Pole Test Report. This report shall include descriptions, tools, and drawings describing the above test.

G. The Owner or its representative reserves the right to be present during testing and shall be notified 2 weeks prior to the start of structure fabrication.

H. Use of any factory tested poles to meet order requirements shall be determined by the Owner.

3.4 WEIGHT

A. The weight of a pole section or a single piece pole shall not exceed 25,000 LBS unless approved by the Owner. Weight shall include arms, base plates, and other attachments.

3.5 MARKING

A. Each piece shall be clearly marked or stamped with its respective erection identification mark.

B. At 5 FT from the base plate (for self-supporting poles) or designated ground line (for direct embed poles), the Supplier shall clearly mark the structure type, structure number (if supplied), overall height, ultimate ground line moment, date of fabrication, and name of pole Supplier.

C. Each pole section shall be marked with an alignment arrow properly located on the exterior surface of the pole section for purposes of insuring each pole section is correctly aligned.

D. Each pole shall be permanently marked on the bottom of baseplate or bearing plate with the following identifying information: structure type, overall height, structure number (if supplied), Owner's name, and date manufactured.

E. V-notch indicators will be marked on the baseplate to represent the transverse axis as shown on the Drawings.

3.6 STRUCTURE PRE-ASSEMBLY

A. All multi-component sub-assemblies should be pre-assembled and match marked by the Supplier, before being shipped. Should the Supplier choose not to complete the trial assembly and match marking process, costs incurred by the Owner or its subcontractors during assembly resulting from improper fit-up will be the responsibility of the Supplier.

3.7 SHIPPING

A. The Owner and/or Owner's representative shall be notified 10 days prior to shipment. All parts required for any one structure shall be in one shipment, if possible. Nuts, bolts, and small hardware shall be boxed or bundled and identified. Each shipment shall be accompanied by a list of parts, identifiable by structure type and number. Salt-treated wood blocking or urethane foams shall not be used for shipping or storing weathering steel poles. All weathering steel poles must be protected from corrosive contaminants such as road salt.

B. The anchor bolt threads shall be protected during shipping.

C. If bolt clusters are shipped assembled they shall be rigid enough to withstand the normal jolts of shipping and handling with no displacement of bolts from the proper positions within the cluster.

D. Unless otherwise authorized by Owner, the anchor bolt cage shall be shipped at least 30 days prior to pole shipment.

E. All fabricated steel sections shall be suitably braced for handling and shipping.

F. Steelwork shall be properly protected during shipping so that parts will not be bent, broken, deformed, stained or otherwise damaged.
   1. Damage to any part of the work due to lack of proper handling or loading by the Supplier shall be repaired or replaced at the Supplier's expense.

END OF SECTION

SECTION 33 71 26.26
POTENTIAL INSTRUMENT TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Induction Voltage Instrument Transformer.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. Institute of Electronic and Electronics Engineers, Inc. (IEEE):
      a. Std 4, Standard for High-Voltage Testing Techniques.
      b. 693, Recommended Practices for Seismic Design of Substations.
      c. C57.13, Standard Requirements for Instrument Transformers.
      d. C57.13.5, Standard of Performance and Test Requirements for Instrument Transformers of a Nominal System Voltage of 115 kV and Above.
      e. C57.13.6, Standard for High – Accuracy Instrument Transformers.
      f. C57.19.00, Standard General Requirements and Test Procedures for Power Apparatus Bushings.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL).

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data:
      a. Provide submittal data for all products including subcomponents specified in PART 2 of this Specification Section.
   2. Fabrication and/or layout Drawings.
      a. Outline Drawing including dimensions, weight and identification of all components and features.
      b. Nameplate Drawing.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Content of Operation and Maintenance Manual:
         1) Instruction and maintenance manual.
         2) Product technical data provided in the submittal.
         3) Outline drawing updated for as-built conditions.
         4) Nameplate Drawing updated for as-built conditions.
         5) Factory test report.
         6) Acceptance testing report.

C. Informational Submittals:
   1. Factory test report.
      a. Certified tests shall be submitted by the manufacturer. Each instrument voltage transformer shall be tested according to NEMA Standard 107 and ANSI C57.13. The following test results shall be provided for each instrument voltage transformer:
         1) Ratio correction factor and phase angle verification at zero burden.
         2) Ratio correction factor and phase angle verification at full rated burden.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. ABB.
   2. Arteche
   3. Trench.
   4. Kulman.
   5. GE.
   6. Ritz.
   7. ITEC
   8. Or Equal

2.2 PERFORMANCE / DESIGN CRITERIA

A. General:
   1. Instrument Transformer to be designed and constructed in accordance with:
      a. IEEE C57.13

B. Ratings and Configurations:
   1. Type: Outdoor, Induction Wound, Oil Filled Voltage Instrument Transformer.
   2. Operation and application: Relaying/Metering.
   1. Insulator: Porcelain.
   2. Configuration:
      a. As indicated on Drawings.
      b. Dual Secondary Winding X and Y
   3. Maximum System Voltage: 38 kV.
   4. Nominal System Voltage: 34.5 kV.
   5. Rated Primary Voltage: 20.125 kV/34.5kV Grd Y.
   6. Frequency: 60 Hz.
   7. Polarity: ANSI standard.
   8. Basic Lightning Impulse level (BIL):
      a. Primary: 200 kV
   9. Voltage Ratio X Winding: [175/300:1]]
   10. Rated Secondary Voltage X Winding: 115/67.08
   11. Voltage Ratio Y Winding: [175/300:1]
   12. Rated Secondary Voltage Y Winding: 115/67.08
   13. Accuracy/Burden Rating: 0.3 Z
   14. Thermal Burden Minimum Rating: 1000 VA
   15. Connections:
      a. As indicated on the Drawings.
      b. Primary Bushings: NEMA 4 Hole
      c. Secondary:

C. Components:
   1. Core and Windings:
      a. Primary winding: Aluminum or copper, double enameled wire with paper insulation, and shielded at both ends.
      b. Secondary windings: Aluminum or copper, double enameled wire with paper insulation and insulated from the core and primary winding.
      c. Tertiary Ferro-Resonance winding: NA
      d. Core: Shall be designed to have a very low flux at the operating voltage
   2. Tank:
      a. Tanks shall be hot dipped galvanized steel, filled with degassed mineral oil, and hermetically sealed.
   3. Ground Lug:

a. Transformers shall be furnished with a ground lug installed (#2 – 250 kcmil Copper).

4. Finish:
   a. Manufacturer's standard corrosion protection system in accordance with IEEE C57.13.
   b. Grey.
5. Accessories:
   a. One female threaded filling opening with plug at top of device, ½" NPT being minimum acceptable size.
   b. One combination drain valve and sampling device, valve must be open to take oil sample, with female threaded drain outlet, ½" NPT being the minimum acceptable size.
   c. Lifting hooks or eyes suitable for lifting the filled unit.
   d. Type ii mineral insulating oil in accordance with ASTM standard specification designation D3487. The supplier shall certify to the purchaser that the oil being supplied shall be classified as PCB-free oil.
   e. Oil level gauge.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: At a minimum, provide all routine tests as specified in IEEE C57.13 in accordance with IEEE C57.19.

2.4 MAINTENANCE MATERIALS

A. NA

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as detailed on the Drawings and in accordance with NFPA 70 and manufacturer's instructions.

B. Transformer locations as shown on the Drawings are intended to be used as a guide.
   1. Field conditions may affect actual transformer location.
   2. Coordinate final location with Owner.

C. Install Voltage Instrument Transformer per detail on the Drawings.

END OF SECTION

2		

SECTION 33 71 26.28
CAPACITIVE COUPLED VOLTAGE INSTRUMENT TRANSFORMER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Capacitive Coupled Voltage Instrument Transformer.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. Institute of Electronic and Electronics Engineers, Inc. (IEEE):
      a. Std 4, Standard for High-Voltage Testing Techniques.
      b. 693, Recommended Practices for Seismic Design of Substations.
      c. C57.13, Standard Requirements for Instrument Transformers.
      d. C57.13.5, Standard of Performance and Test Requirements for Instrument Transformers of a Nominal System Voltage of 115 kV and Above.
      e. C57.13.6, Standard for High – Accuracy Instrument Transformers.
      f. C57.19.00, Standard General Requirements and Test Procedures for Power Apparatus Bushings.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data:
      a. Provide submittal data for all products including subcomponents specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   2. Fabrication and/or layout Drawings.
      a. Outline Drawing including dimensions, weight and identification of all components and features.
      b. Nameplate Drawing.
   3. Certifications:
      a. NA

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Content of Operation and Maintenance Manual:
         1) Instruction and maintenance manual.
         2) Product technical data provided in the submittal.
         3) Outline drawing updated for as-built conditions.
         4) Nameplate Drawing updated for as-built conditions.
         5) Factory test report.
         6) Acceptance testing report.

C. Informational Submittals:
   1. Factory test report.
      a. Certified tests shall be submitted by the manufacturer. Each CVT shall be tested according to NEMA Standard 107 and ANSI C57.13. The following test results shall be provided for each instrument voltage transformer:
         1) Ratio correction factor and phase angle verification at zero burden.
         2) Ratio correction factor and phase angle verification at full rated burden.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. ABB.
   2. Arteche
   3. Trench.
   4. Kulman.
   5. GE.
   6. Ritz.
   7. ITEC
   8. Or Equal

2.2 CAPACITIVE COUPLED INSTRUMENT TRANSFORMER

A. General:
   1. Capacitive Coupled Instrument Transformer to be designed and constructed in accordance with:
      a. IEEE C57.13
   2. FM Global approved.

B. Ratings and Configurations:
   1. Type: Outdoor, Capacitive Coupled, Oil Filled Voltage Instrument Transformer.
   2. Operation and application: Relaying/Metering.
   1. Insulator: Porcelain.
   2. Configuration:
      a. As indicated on Drawings.
      b. Dual Secondary Winding X and Y
   3. Maximum System Voltage: 362 kV.
   4. Nominal System Voltage: 345 kV.
   5. Rated Primary Voltage: 209 kV.
   6. Frequency: 60 Hz.
   7. Polarity: ANSI standard.
   8. Basic Lightning Impulse level (BIL):
      a. Primary: 1300 kV
   9. Voltage Ratio X Winding: 1800/3000:1
   10. Rated Secondary Voltage X Winding: 115/69
   11. Voltage Ratio Y Winding: 1800/3000:1
   12. Rated Secondary Voltage Y Winding: 115/69
   13. Accuracy/Burden Rating: 0.3ZZ
   14. Connections:
      a. As indicated on the Drawings.
      b. Primary Bushings: NEMA 4 Hole

C. Components:
   1. Core and Windings:
      a. Primary winding: Aluminum or copper, double enameled wire with paper insulation, and shielded at both ends.
      b. Secondary windings: Aluminum or copper, double enameled wire with paper insulation and insulated from the core and primary winding.
      c. Tertiary Ferro-Resonance winding: NA
      d. Core: Shall be designed to have a very low flux at the operating voltage
   2. Tank:
      a. Tanks shall be {hot dipped galvanized steel} {cast aluminum}, filled with degassed mineral oil, and hermetically sealed.
   3. Ground Lug:

a. Transformers shall be furnished with a ground lug installed (#2 – 250 kcmil Copper).

4. Finish:
   a. Manufacturer's standard corrosion protection system in accordance with IEEE C57.13.
   b. Grey.
5. Accessories:
   a. One female threaded filling opening with plug at top of device, ½" NPT being minimum acceptable size.
   b. One combination drain valve and sampling device, valve must be open to take oil sample, with female threaded drain outlet, ½" NPT being the minimum acceptable size.
   c. Lifting hooks or eyes suitable for lifting the filled unit.
   d. Type ii mineral insulating oil in accordance with ASTM standard specification designation D3487. The supplier shall certify to the purchaser that the oil being supplied shall be classified as PCB-free oil.
   e. Oil level gauge.
   f. Overvoltage Protective Gap
   g. Compensating Reactor
   h. Ferroresonance suppression with damping resistor

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: At a minimum, provide all routine tests as specified in IEEE C57.13 in accordance with IEEE C57.19.

2.4 MAINTENANCE MATERIALS

A. NA

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as detailed on the Drawings and in accordance with NFPA 70 and manufacturer's instructions.

B. Capacitive Coupled Voltage Instrument Transformer locations as shown on the Drawings are intended to be used as a guide.
   1. Field conditions may affect actual transformer location.
   2. Coordinate final location with Owner.

C. Install Capacitive Coupled Voltage Instrument Transformer per detail on the Drawings.

END OF SECTION

SECTION 33 72 33.13
UTILITY SUBSTATION RELAYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Transmission Protection.
   2. Distribution Protection.
   3. Transformer/Bus Protection.
   4. Breaker Protection.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Code of Federal Regulations (CFR):
      a. 47 CFR Part 15 Subpart B, Unintentional Radiators.
   2. Underwriters Laboratories, Inc. (UL):
      a. 508, Standard for Safety Industrial Control Equipment.
      b. 508A, Standard for Safety Industrial Control Panels.
   3. International Electrotechnical Commission (IEC):
      a. 60255, Measuring Relays and Protection Equipment.
      b. 61000, Electromagnetic Compatibility.
   4. Institute of Electrical and Electronics Engineers (IEEE):
      a. C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
      b. C37.111, Measuring Relays and Protection equipment – Part 24: Common Format for Transient Data Exchange (COMTRADE) for Power Systems.
      c. C37.118.1, Standard for Synchrophasor Measurement for Power Systems.

1.3 SYSTEM DESCRIPTION

A. This Specification specifies components used within other equipment as referenced in other technical specifications.

B. This Specification is used to specify protection relays for substation application:

1.4 SUBMITTALS

A. Shop Drawings:
   1. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification:
         1) When components are used within equipment specified in another Section, submittal data for components specified herein shall be included with the submittal for the equipment the components are used in.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Content of Operation and Maintenance Manual:
         1) One complete product manual hard copy, and one PDF format electronic copy.

C. Informational Submittals:
   1. Verification of compliance with general requirement including: environmental conditions, reliability, and compliance with applicable standards.
   2. Product Warranty information, and registration.
   3. Functional Test Plan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Transmission Protection Relays:
      a. Schweitzer Engineering Laboratory (SEL).
   2. Distribution Protection Relays:
      a. Schweitzer Engineering Laboratory (SEL).
   3. Transformer/Bus Protection Relays:
      a. Schweitzer Engineering Laboratory (SEL).
   4. Breaker Protection Relays:
      a. Schweitzer Engineering Laboratory (SEL).

2.2 TRANSMISSION PROTECTION RELAYS

A. General Requirements:
   1. Two (2) Line Protection relays to be coordinated with AEP Indiana

B. Communication:
   1. TBD

C. Security:
   1. Password Protection: The relay shall have a tiered system of multiple levels of passwords to safeguard the data, control, and protection functions.

2.3 DISTRIBUTION/BREAKER PROTECTION RELAYS

A. General Requirements:
   1. One (1) Breaker Protection relay for each HV and MV breaker

B. Communication:
   1. TBD

C. Security:
   1. Password Protection: The relay shall have a tiered system of multiple levels of passwords to safeguard the data, control, and protection functions.

2.4 TRANSFORMER/BUS PROTECTION RELAYS

A. General Requirements:
   1. Two (2) Transformer Protection relays to be coordinated with AEP Indiana
   2. One (1) Medium Voltage Bus Protection relay to be coordinated with AEP Indiana

B. Communication:
   1. TBD

C. Security:
   1. Password Protection: The relay shall have a tiered system of multiple levels of passwords to safeguard the data, control, and protection functions.

2.5 RTAC

A. General Requirements:
   1. One (1) SEL RTAC to be coordinated with AES Indiana

B. Communication:
   1. TBD

C. Security:
   1. Password Protection: The relay shall have a tiered system of multiple levels of passwords to safeguard the data, control, and protection functions.

2.6 FABRICATION

A. The device shall be manufactured in the United States.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Connect relay (following manufactures instructions) in accordance with project documentation and drawings.

C. Only qualified relay technician with a minimum of five years of experience with protection relays shall service, install, and maintain the relay.

END OF SECTION

SECTION 33 72 33.19
PROTECTION AND CONTROL PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Protection and Control Panels.

B. Related Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. C2, National Electrical Safety Code.
      b. Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
   2. ASTM International (ASTM).
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. C37.21, IEEE Standard for Control Switchboards.
      b. C37.90.1, IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
   4. National Electric Manufacturers Association (NEMA).
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   6. Underwriters Laboratories, Inc. (UL).

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification:
         1) When components are used within equipment specified in another Section, submittal data for components specified herein shall be included with the submittal for the equipment the components are used in.
      b. Mounting and loading information.
      c. Installation instructions and procedures.
      d. See Specification Section 26 05 00 for additional requirements.
   2. Fabrication and/or Layout Drawings:
      a. Front panel elevations.
      b. Wiring diagrams.
      c. Bill of material for each panel.
      d. Nameplate schedule.
      e. Fabrication details.
   3. Certifications:
      a. Acknowledgement that products submitted meet requirements of standards referenced.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Content of Operation and Maintenance Manual:
         1) One complete product manual hard copy, and one PDF format electronic copy.

C. Informational Submittals:
   1. Product Warranty information, and registration.
   2. Functional Test Plan.
   3. Factory Acceptance Test Report.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Clark Control Systems.
   2. Electrical Power Products.
   3. FMH Control Systems.
   4. Keystone Electric Manufacturing.
   5. Schweitzer Engineering Laboratories (SEL).
   6. Specialty Electrics, Inc.
   7. Or Equal

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Operating Conditions:
   1. Control panel will be installed indoors in a dry, temperature controlled environment; however, the relay panel shall be designed for operation between [20] DEG below to [70] DEG above Celsius temperature range.
   2. Altitude above mean sea level: Less than 3300 FT.
   3. Seismic design category: C

B. Electrical Requirements:
   1. Wiring and Termination:
      a. Control panel wire shall be #12 AWG, Type SIS, 600 Volt with extra flexible (65 strand, or equal) copper conductors, except #18 AWG (16 strand) may be used for annunciator wiring. Conductors shall be U.L. listed.
      b. Wiring for analog outputs from transducers or similar devices shall be #20 AWG, 300 V, stranded copper twisted pair cable with overall PVC jacket, unless otherwise specified. Each twisted pair shall be foil shielded and contains a minimum #22 AWG copper drain wire for termination and grounding at the respective terminal block.
      c. Wire terminals shall be ring type, tin plated copper with insulated sleeves, barrel size 12-10 for #12 AWG and 22-16 for #18 and #20 AWG, with proper ring size for mating stud. Terminals shall be "Plasti-Grip", or equal.
      d. Provide a 1/4 IN by 1-1/2 IN copper ground bus bar.

2.3 MATERIALS

A. Use only new materials free of rust or other defects.

B. Relay panel shall be formed from U.S. Standard #11 gauge cold rolled steel.

C. Nameplates:
   1. A nameplate shall be provided for each device as listed on the specified drawings.
   2. Nameplates shall be of plastic construction, white engraving on black with size and lettering as specified. Nameplates shall be attached to the relay panel with 1/32 IN double-adhesive foam tape.
   3. All devices, including those not requiring nameplates, such as terminal boards and fuses, shall be labeled on the rear of the panel. Labels shall be self-adhesive white markers, type written with device designations corresponding to those used on wiring diagrams.
   4. Provide a manufacturer's nameplate in accordance with the latest revision of ANSI C37.21. Nameplate shall include:
      a. Manufacturer's Name and Address.
      b. Manufacturer's Identification References.
      c. Year of Manufacture.

2.4 COMPONENTS

A. Relays and draw out case devices, recording instruments, meters, test switches and all other front panel mounted devices shall be semi-flush mounted, back connected, unless specified otherwise.

B. All AC relays and devices shall be rated for operation on 60 Hz AC system.

C. Nominal control voltage will be 125 VDC. All control circuits and devices shall be rated for operation from 105 V to 132 V.

D. Instrument and Control Switches:
   1. Instrument and control switches shall be Electroswitch Series 24. Stage configuration, escutcheon and handle as specified.
   2. Circuit breaker control switches shall be heavy duty, 20 Amps, 600 V, with standard pistol grip handle dust cover, target and spring return from trip and close positions. Stage configuration and escutcheon to be as specified. Contacts shall be electrically separate. Switches shall be Electroswitch Series 24.

E. Indicating Lamps:
   1. Bulbs shall be removable from the front of the panel.
   2. Furnish GE Type ET-16.

F. Terminal Boards:
   1. Shall be one piece molded phenolic with barriers, 150 DEGC rated, 600 V, 20 Amps with strap screw connections.
   2. Terminal boards shall be 12-point with white marking strips, G.E. Type EB-25, or equivalent.
   3. Terminal boards for current circuits shall be 4-point with copper shorting strip, G.E. Type EB-27 or equivalent.

G. Fuse Blocks and Fuse:
   1. Fuse blocks shall be phenolic construction with side barriers, 250 V with rating and number of poles as specified. Fuse blocks shall be UL listed.
   2. One-time fuses shall be Class H, 10,000 Amp RMS symmetrical interrupting rating, 250 V.
   3. Furnish Bussman Type NON or equal, rating as specified.
   4. Fuses shall be UL listed.

H. Pre-assembled Cables:
   1. Furnish pre-assembled cables as indicated on the specification drawings.
   2. Unless indicated otherwise on specification drawings, Vendor is responsible for determining lengths of all cables between devices that will be installed in the field by others. Cables shall reach from device to device with an excess length not greater than five feet.
   3. Vendor shall provide a cable schedule to the Engineer for approval detailing the lengths and termination points of all vendor furnished cables.
   4. All cables furnished loose by the Vendor shall be marked with termination points on packaging.

2.5 FABRICATION

A. Enclosure:
   1. Panel stiffeners, 1/4 IN by 1-1/2 IN bar, shall be welded at locations where required for rigidity.
   2. The welded internal framed structure shall be adequately braced to insure rigidity of all panel surfaces and the enclosure overall.
   3. The frame structure shall include lifting attachments on the top and base anchor bolt provisions for mounting to the floor.
   4. All surfaces shall be planar and free from warping and buckling.
   5. All panel edges shall have a minimum radius of 3/16 IN.
   6. No welds, rivets, bolt heads, or other connection means shall be apparent from the outside.
   7. All exterior joints shall be ground smooth.
   8. Panel fronts shall include drilled and tapped rails for mounting 19 IN rack equipment, when required.

9. All rear panel mounted equipment shall be mounted on mini-channel welded to side wings provided with the rack or to the back of the front panels as noted on the drawings. Placement of brackets shall not interfere with access to terminal board or device connections.
10. After cutouts and drillings are complete, grind joints, edges and welds smooth.
11. Provide hardware for all required field assembly. Each hardware item shall be packaged and tagged to indicate its purpose.

B. Surfacing and Painting:
1. Remove all weld splatter, burrs, and other surface defects as required to give a smooth finish and to result in an attractive appearance of the finished product.
2. Remove all oil, grease and dirt with cleaners and solvents formulated for such purpose.
3. Phosphatize all bare metal surfaces.
4. Apply one coat of rust inhibiting primer, one coat of gray sealer undercoat, and two coats of ANSI #61 gray semi-gloss enamel (Munsell 8.3G 6.10/0.54) to all external metal surfaces of the relay panel rack, mounting plates, brackets, etc. Final color application to all relay panels and components shall be made in one operation to assure no appreciable difference of color shade.
5. Interior shall be white.

2.6 MAINTENANCE MATERIALS

A. Provide two aerosol cans of touch-up paint from the same color batch as used for the relay panel.

2.7 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Test:
1. Factory tests shall be conducted on each relay panel prior to shipment to the site. Factory testing shall address the following items as a minimum:
a. Check all devices, equipment and wiring to insure that they are properly rated, installed, and labeled. Each wire shall be individually checked as being properly terminated to terminals as indicated on the wiring diagram.
b. Check continuity of all current circuits and insure that adequate insulation exists between ground and control wiring.
c. Perform operating sequence tests for all relay systems, where applicable.
2. Provide Owner with one signed electronic copy of all test results. Test data shall be supplied not later than five days after shipment.

PART 3 - EXECUTION

3.1 PREPARATION

A. Lock washers shall be used on all relay stud connections.

B. No more than two wires shall be terminated on any one screw connection and no more than three wires on any one stud or bolted connection.

C. Wiring shall be installed in a workmanlike manner. Wires shall be bundled by use of nylon cable ties, at intervals as required to provide a neat appearance. Size of individually tied bundles shall be limited to 1-1/4 IN diameter.

D. Wire duct for use in routing and support of conductors shall be Panduit, "Panduct", or equal. Other approved means for supporting wiring include screw applied and epoxy applied tie mounts. Self-adhesive tie mounts are not allowed.

E. All connections between devices on a panel and any point outside the panel shall be made through terminal boards, unless otherwise noted.

F. Provide spare terminal board terminals to the extent of 10% used, with a minimum of one spare 12-point terminal board.

G. Provide specified grounding connections from terminal blocks to copper ground bus.

H. All relay panel conductors shall be labeled at both ends with a permanent labeling system to identify the other ends' termination point.

I. Terminals shall be attached to wire with ratcheting type compression tools to ensure proper connection.

J. All spare relay contacts shall be connected to terminal boards for future use.

3.2 INSTALLATION

A. Install protection and control panels in accordance with the manufacturer's instructions.

3.3 FIELD QUALITY CONTROL

A. The Owner and/or Engineer will conduct tests and inspection as he deems necessary to determine that equipment functions properly after installation. Any special test equipment will be furnished by others.

B. If equipment fails to function properly because of defects, Seller will make necessary corrections and, upon completion thereof, demonstrate to Owner that these defects have been corrected.

END OF SECTION

SECTION 33 75 19
GAS HIGH-VOLTAGE CIRCUIT BREAKER

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
1. 345kV SF_6 outdoor, dead tank, frame mounted power circuit breaker.
2. Furnish all labor, equipment, and material for the following:
   a. Filling with insulating medium.
   b. Making all necessary adjustments.
   c. Checkout and field testing.
3. Provide factory trained service representative for technical direction, inspections, and testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
1. Perform work in accordance with best present-day installation and manufacturing practices.
2. Unless specifically noted to contrary, conform with and test in accordance with applicable sections of latest revisions of following codes and standards:
   a. American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE):
      1) C2, National Electrical Safety Code (NESC).
      2) C37.04, IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
      3) C37.04, IEEE Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V
      4) C37.06, American National Standard Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
      5) C37.09, Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
      6) C37.11, Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis or a Total Current Basis.
      7) C57.13, IEEE Standard Requirements for Instrument Transformers.
      8) C57.19.00, IEEE Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings.
      9) C57.19.01, IEEE Standard Performance Characteristics and Dimensions for Outdoor Power Apparatus Bushings.
      10) C76.1, Standard General Requirements and Test Procedures for Outdoor Apparatus Bushings.
      11) C76.2, Electrical, Dimensional, and Related Requirements for Outdoor Apparatus Bushings.
   b. American Society for Testing and Materials (ASTM):
      1) ASTM D2472, Specification for Sulfur Hexafluoride.
      2) D3487, Specifications for Mineral Insulating Oil Used in Electrical Apparatus.
   c. National Fire Protection Association (NFPA):
      1) NEC, National Electrical Code.
3. Conflicts between referenced codes and standards: Code or standard establishing more stringent requirements shall be followed. Engineer shall be the final judge as to which requirement is more stringent.

B. Qualifications:

1. The manufacturer shall be ISO 9000 Certified, and have at least 10 years of manufacturing experience manufacturing power circuit breakers.

C. Definitions
   1. Dead Tank Design: Interrupters contained within a grounded metal tank.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data
      a. Submit product technical data including acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
      c. Fabrication and/or layout drawings.
      d. Certifications.
      e. Test reports.
   2. Nameplates (s)
      a. Power circuit nameplate drawings shall be submitted for the operator, current transformers, and the breaker.
      b. Operator Nameplates shall include at a minimum:
         1) Serial Number
         2) Date of Manufacture
         3) Close and Trip voltage ranges and the associate amperages
         4) Close motor operating voltage
         5) Close motor start and run currents
      c. Current Transformer Nameplates shall include at a minimum
         1) Current ratios for all taps
         2) Turn Ratios for all taps
         3) Tap connections points for all taps
         4) Metering and protective relay accuracy class
      d. Breaker Name Plates shall include at a minimum
         1) Rated Maximum voltage
         2) Rated interrupting time
         3) Rated continuous current
         4) Rated short circuit current
         5) Rated frequency
         6) Full wave impulse withstand
         7) Weight of breaker with gas
         8) Weight of SF6 gas
         9) Rated operating pressure
         10) Minimum operating pressure
         11) Rated capacitive current switching
         12) Serial number
   3. Breaker Outline (s)
      a. The power circuit breaker outline will indicate the plan and profile of the power circuit breaker and all necessary dimensions, as well as outline the terminal and anchoring details.
      b. Drawings shall indicate all required maintenance areas and pull space for equipment removal.
   4. Schematic and Wiring Drawings
      a. Detailed operational schematics and point to point wiring diagrams shall be submitted with all submittals.
   5. Current Transformer Performance
      a. Current transformer performance curves and required design data.

B. Informational Submittals:

1. Production schedule and test schedule within four weeks of receipt of order. The schedule shall show all milestones including, production, drawing submittals and testing and shipment.
    2. Certified copies of all production and optional test results.

C. Contract Closeout Information:
    1. Operation and Maintenance Data:
        a. Provide two hard copies and one electronic copy of composite O&M manuals (instruction books) including data from sub suppliers in a common binder arrangement.
        b. Content of Operation and Maintenance Manual:
            1) Instruction and maintenance manual.
            2) Product technical data provided in the submittal.
            3) Outline drawing updated for as-built conditions.
            4) Nameplate Drawing updated for as-built conditions.
            5) Factory test report.
            6) Field Acceptance testing report.

1.4 DELIVERY, STORAGE, AND HANDLING

A. The Owner shall notify the Contractor when equipment is ready for shipment. Such notice shall include projected routing and estimated time in shipment.
    1. All equipment in this contract with a common delivery destination shall be made in a common shipment. The Seller shall be responsible for all incidental costs incurred by the Owner due to separate shipments of such equipment.
    2. Immediately after shipment, Seller shall notify the Engineer of transportation carrier and all transfers and references to permit follow-up on status of shipment and delivery.

B. Prior to shipment, all gauge and indicator glass shall be thoroughly cleaned and covered with non-adhesive shipping protectors.

C. Circuit breakers shall be shipped as complete as practical. In the case of circuit breaker in which shipment or design restrict the circuit breaker from being completely assembled, the units shall have factory “plug and play” pre-wired connectors. Gas interrupters shall be pre-charged prior to shipment, with any supplemental gas furnished as part of one single shipment.

1.5 DEFECTIVE EQUIPMENT

A. Equipment may be removed from operation for examination, adjustment, alteration, or change only at time approved by Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
    1. ABB Inc.
    2. Siemens Energy Inc.
    3. Mitsubishi Electrical Power Products Inc.
    4. Or equal

2.2 PERFORMANCE / DESIGN CRITERIA

A. Power Circuit Breaker Ratings
    a. Type – 3 pole gang operated, SF6 insulated, Dead Tank
    b. Normal Operating Voltage (kV) – 345 kV
    c. Maximum Continuous Operating Voltage (kV) – 362 kV
    d. Continuous Current Amperes – 2000 amps
    e. Symmetrical Interrupting Capability (kA) – 50 kA
    f. Interrupting Time (Cycles)-3 cycles or less
    g. System Frequency (Hz) – 60 Hz

h. Control Voltage Trip Circuits (Volts DC) – 125 VDC
i. Control Voltage Close Circuit (Volts DC) – 125 VDC
j. Motor Charging Voltage
   1) 125 VDC and 120 or 208 VAC
k. System Effectively Grounded (Yes/No) – Yes
l. Breaker Operating Duty – O-0.3s-CO-3m-CO

B. Power Circuit Breaker Bushings
1. The power circuit breaker bushings shall have at a minimum the ampacity rating, the full wave BIL, and maximum continuous operating voltage of the power circuit breaker.
2. The bushings shall conform to IEEE standards C57.19.00 and C5.19.01 for apparatus bushings.
3. Minimum Creep (inches)

C. Bushing Current Transformers
1. Multi ratio bushing current transformers shall have fully distributed windings. Terminals 1,3,5 and 2,4,6 bushing current transformers position X, Y, and Z shall be matched across each position unless specifically noted in this specification, and each position ratings is listed below.
2. X, Y, Z Position all Bushings:
   a. Ratio – 2000:5
   b. Multi Ratio/Single Ratio – Multi Ratio
   c. Relaying Accuracy Class – C1200
   d. Metering Accuracy Class (if required) – 0.3B1.8@ Full Ratio
   e. Temperature Class - 105°C
   f. Frequency – 60 Hz
   g. Insulation Level – 0.6 kV Class
   h. Continuous Thermal Rating Factor – 2.0
   i. Secondary Resistance Per Turn – 0.0025 Ohms Maximum

D. Services Condition:
1. Environmental conditions will be based on installation at the project site.
   a. Altitude: [600] feet.
   b. Seismic Zone – [B]
   c. Temperature Range (F) – [-40F to + 104F]
   d. Annual Precipitation (in) – [2.5] inches
   e. Annual Snow Fall (in) – [60] Inches
   f. Average and Maximum Recorded Wind (MPH) –[90 mph Average, 130 mph Maximum]
   g. Humidity Range [50-55%]

2.3 MATERIALS

A. Interrupter Tank(s)
1. The Interrupter Tanks shall be fabricated from cast aluminum and shall be designed to withstand all stress encountered in shipping, installation and normal operation.
2. The Interrupter tanks shall be designed to meet the ASME 'Boiler and Pressure Vessel Code' requirements, and the tank shall have the ASME "U" stamp. All Bolted tank cover interfaces to the main tank shall be neoprene gasketed, and the gaskets shall be re-useable.

B. SF6 Gas System
1. All piping and fittings on the interrupter tanks for the SF6 gas system shall be stainless steel or bronze.

C. Circuit Breaker Support Structure
1. The circuit breaker support structure shall be galvanized steel and painted ANSI 70 grey.

D. Operator and Control Cabinet
1. The Operator and control cabinet shall be NEMA 3R and painted ANSI 70 grey.

2. The interior of the control cabinet shall be painted white. All surfaces shall be thoroughly cleaned, by means of sand blasting or shot blasting or a chemical means prior to painting.
3. The control cabinet doors hardware shall be made of stainless steel.

E. Bushings
1. The bushings shall be porcelain and shall be ANSI 70 grey to match other painted structures.

F. Bushing Current Transformers
1. Not Applicable

2.4 COMPONENTS

A. Interrupter Tank(s)
1. Each pole shall be provided with a gas density gauge and temperature compensated gauge mounted as near the tank as practical. All density gauges shall be designed and mounted so they are clearly visible from grade without the need for opening any doors.
2. Each interrupter tank shall have a pressure relive device. Each interrupter tank shall have heaters.
3. The heaters shall allow the circuit breaker to function at the temperature and climatic conditions specified in Section 2.2.1, the heaters shall be capable of operation at 120 VAC or 208 VAC.

B. SF6 Gas System
1. The SF6 gas system shall have the following cutouts and alarms:
   a. Low pressure cutout switch wired to an auxiliary relay integral to the trip coil #1 control circuit that blocks closing and tripping of trip coil #1, contacts from this low pressure cutout auxiliary relay shall be made available for customer use as an alarm.
   b. A second low pressure cutout switch wired to an auxiliary relay integral to the trip coil #2 control circuit that blocks tripping of trip coil #2, contacts from this low pressure auxiliary relay shall be made available for customer use as an alarm.
   c. Gas density loss
   d. Spring stored energy loss
   e. Breaker trip
   f. Operating mechanism alarm
2. These points shall be adjustable in the field. All contacts shall be rated 125 VDC and 16 amps. The SF6 system shall have a quick disconnect fill point and lockable shut off valve.
3. The circuit breaker shall be shipped with SF_6 gas at pressures in accordance with the US Department of Transportation (DOT) regulations.
4. The necessary SF_6 required for completion of filling shall be shipped in returnable DOT approved Cylinders.
5. The SF_6 Leak rate from the circuit breaker, in its entirety including the bushings shall not exceed 1.0% per year.

C. Circuit Breaker Support Structure
1. The circuit breaker support structure shall provide clearance to supporting surface from live parts which meet the NESC requirements.
2. The support structure shall provide at least 2’0” of clear space from the bottom of the control cabinet for conduit and cable entrance. Each support structure shall be provided with two NEMA four hole ground pad positions.
3. The frame and circuit breaker shall be suitable for mounting at grade on a foundation.
4. The frame or frames shall be suitable for mounting on and bolted to a foundation in the field.

D. Operator and Control Cabinet
1. Operator

a. The operating mechanism shall be a motor charged spring energy storage system. The charging motor shall be AC/DC compatible and have an auto transfer circuit to transfer from the primary AC circuit to the secondary DC circuit and each shall be individually protected by a circuit breaker.
b. The circuit breaker operator shall be mechanically and electrically trip free in any position and designed to be anti-pumping.
c. The operating mechanism shall be charged in 15 seconds or less.
d. The operating mechanism shall have a slow close feature.
e. The operator shall be capable of being manually charged via the use of extension levers or bars.
f. The operator shall be provided with an interlock mechanism to prevent closing when not fully charged.
g. Each operator shall have an indicator, visible when the cabinet door is open or closed to indicate that the energy storage device is in the charged or discharged state.
h. The operating mechanism shall be provided with a switch which indicates alarm and blocks operation of closing with insufficient energy storage. These shall be wired to the control cabinet for remote alarm and into the close circuit to block closing when initiated.

2. Control Cabinet
a. All three pole, gang operated circuit breakers shall have a single integral control cabinet in which the control accessories, wiring terminals for external connection and operating mechanism are mounted.
b. The control cabinet shall have access for control cables from the bottom by means of removable plates.
c. The control cabinet shall have clear access to the terminals for terminating wiring and field cables.
d. The doors shall be gasketed, removable and provisions shall be made for padlocking.
e. Heaters shall be provided in the control cabinet, and allow the circuit breaker, circuit breaker control circuitry, and circuit breaker operator to function at the environmental conditions specified in section 2.2.1. The heater shall be capable of reducing condensation in the control cabinet. The heaters shall be capable of operation at 120 VAC or 208 VAC [480 VAC].
f. A 120 VAC GFI convenience outlet shall be furnished mounted on the exterior of the control cabinet.
g. The control cabinet shall have a light which is activated by opening of the cabinet door.
h. Permanently label all devices, control accessories and terminal blocks in the control cabinet. Nameplates shall be black letters on white background. The labeling must correspond to the function of the device and the wiring diagram.
i. The control cabinet shall be completely factory wired and assembled.
j. All auxiliary power, control, alarm and other circuit requiring external connections shall be wired to the terminal blocks in the control cabinet.
k. Current transformers shall have shorting type terminal blocks and a separate ground terminal on each block.
l. All interior wiring shall be installed in Panduit and neatly routed through the control cabinet.
m. The terminal blocks shall be provider with washer head binding screws, covers, and white terminal markings strips.
n. Provide a copper ground bus, tapped for all internal connections in addition to a minimum of six spares for external use.

E. Bushings
1. The bushings shall be insulated with SF6 in a common system with the interrupters. The bushings shall have NEMA 4 terminals.

F. Bushing Current Transformers

1. All bushing current transformers shall conform to the IEEE C56.13 requirements and be of the slipover bushing type.
2. All bushing current transformers shall be wired to shorting type terminal blocks mounted in the control cabinet. The bushing current transformers shall be supplied with the terminals in the shorted position.
3. The bushing current transformer shall be supplied with an etched or embossed nameplate in accordance with ANSI standards.

G. Circuit Breaker Control Trip and Close Circuits
1. The circuit breaker shall be supplied with two trip coils, mechanically and electrically independent. The trip coils shall be designed such that its use, loss or damage of either does not impact the functionality of the other. Surge suppression shall be supplied on each trip coil.
2. A fusible two pole blade disconnect shall be supplied for each trip coil circuit. The trip coil circuits shall be supplied with slugged fuses in each pole of the trip coil fusible disconnects. The trip coil circuit shall be designed to limit DC current to 15 amps or less (instantaneous and steady state).
3. Each trip coil circuit shall have a prewired 'b' (normally closed) contact for the use in breaker status and indication. The 'b' contact shell be prewired to the DC negative of the trip coil circuit and the unconnected side shall be wired to a terminal for external connection.
4. Each trip coil circuit shall have a prewired trip coil monitor prewired (EMAX RAW-1D or equivalent) to monitor the trip coil status and be prewired to a 'b' contact to prevent false indication on a breaker open condition. The auxiliary alarm contact of the trip coil monitor for each trip coil shall be wired to terminals for external connection.
5. A reduction in gas pressure below the minimum operating levels shall operate both trip coils to initiate a breaker trip, this shall be called a low pressure cutout. The low pressure cutout shall also block local and remote tripping functions, and shall block local and remote closing functions.
6. The circuit breaker shall be supplied with one close coil and anti-pumping circuitry. Surge suppression shall be supplied on the close coil.
7. A fusible two pole blade disconnect shall be supplied for the close coil circuit. The close circuit shall be supplied with fuses in each pole appropriately sized for the close circuit. The close circuit shall be designed to limit DC current to 15 amps or less (instantaneous and steady state).
8. Both trip circuits and the close circuit shall be supervised by a single 'trip-normal-close, pull for remote' rotary control switch located in the control cabinet (Electroswitch 74206RF with engraving 019C-3B36 or equivalent). The normal position shall cutout all remote functions (trip and close). All remote function contacts for trip and close supervision shall be designed so that the remote cut out can be bypassed by jumper. Each remote cutout shall have the cutout contract terminals wired to a breaker terminal for external bypass jumper wiring. The normal position shall be a spring return position and the trip position shall be counter clockwise and the close position shall be clockwise. The remote position shall be operated by pulling the switch handle out. At least one spare auxiliary contacts shall be provided on the 'trip-normal-close, pull for remote' rotary switch for the trip and close positions to provide the status of the switch. At least two spare auxiliary contacts shall be provided on the 'trip-normal-close, pull for remote' rotary switch for the normal and remote positions to provide the status of the switch.

H. Circuit Breaker Auxiliary Control and Control Devices
1. Furnish a minimum of ten each 'a' (normally open) and 'b' (normally closed) auxiliary breaker contacts for customer use. These shall be in addition to any auxiliary breaker contacts required for the circuit breaker operation.
2. Auxiliary breaker contacts shall be mechanically interlocked to the circuit breaker operating mechanism.
3. A circuit breaker shall be supplied for the auxiliary circuit breaker AC power circuit.

4. A circuit breaker shall be supplied for each of the auxiliary circuit breaker AC power branch circuits including the motor spring charging circuit, the light circuit, the heater circuit, and the convenience outlet circuit.

I. General Wiring (Trip, Close, Auxiliary Control Circuits)
   1. Furnish and install all wiring and raceway necessary for a fully functional circuit breaker.
      a. All wiring and raceway shall be installed prior to shipment when all poles, control cabinet and operating mechanism are installed on a common frame.
      b. All wiring shall be in accordance with NEC guidelines.
      c. All conduit shall be rigid GRS (Galvanized Rigid Steel), PVC (Poly vinyl Chloride compounds), plastic, EMT (electric metallic tubing), or IMT (Intermediate grade metallic tubing) are not acceptable.
      d. All internal cabinet wiring shall be SIS insulated 600 volt, 90C rated. All wiring shall be stranded copper, # 14 AWG minimum. All wiring for the current transformer shall be #10 AWG minimum.
      e. Splicing of wires shall not be permitted.
      f. All wiring shall be identified with permanent labels, and identified with opposite end designations at each termination.
      g. All wiring terminals shall be ring terminal type, seamless barrels and the barrel uninsulated.
      h. Extra flexible or fine standing shall be used when wiring crosses between surfaces which are hinged together.

J. Terminal Blocks
   1. Terminal blocks shall be rated for 20 ampere minimum.
   2. There shall be no more than two wires terminated per terminal screw.
   3. Each terminal block shall be identified by a permanent marking, engraving, or embossing.
   4. Terminal blocks shall be vertically mounted.
   5. Provide means to secure external cables to terminal blocks.
   6. Provide a 4 point terminal block for terminating AC supply to the control cabinet. This terminal block shall accommodate #10 AWG through #4 AWG.
   7. Provide a spare terminal block (at least 12 point), 20 ampere screw type for future use.

2.5 ACCESSORIES

A. Each circuit breaker shall be supplied with the following accessories.
   1. Each circuit breaker shall have a position indicator visible from the outside of the circuit breaker control cabinet.
   2. Each circuit breaker shall have an operation counter. The operation counter shall be designed and mounted so they are clearly visible from grade without the need for opening any doors.
   3. Each circuit breaker shall have a manual spring charging device.
   4. Each circuit breaker shall be supplied with any special assemblies or filling devices necessary for the safe operation, installation, and maintenance of the circuit breaker.
   5. Automatic features to prevent overcharging of the spring charge mechanism.
   6. The circuit breaker shall have lifting eyes so the circuit breaker can be installed or removed via the use of a crane or boom. In the case of individual pole circuit breakers, each pole and control cabinet shall have lifting eyes which can be used for installation and removal with a crane or boom.

2.6 SOURCE QUALITY CONTROL

A. Each source (manufacturer) shall have a minimum of ten years of professional experience supplying the product/products indicated in this specification.

B. Factory Testing
   1. Factory production test shall be in accordance with applicable provisions of ANSI, IEEE and NEMA standards.
   2. The Owner and Engineer reserves the option to witness factory testing prior to shipment.

3. Notify Owner and Engineer at last 14 days in advance of the stat of Factory test.
4. Copies of all production and optional tests results shall be made available within five days of testing.

2.7 MAINTENANCE AND MAINTENANCE MATERIAL

A. The circuit breaker shall be designed and manufactured for reasonable and convenient access, for testing and maintenance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receiving:
1. Furnish all labor, material and equipment required for receiving and inspection.
2. If any damage is observed or suspected, provide written report to OWNER describing damage and proposed remedy (include pictures of any visible damage)
3. Repair damage to OWNER's satisfaction.
4. Verify that all parts have been received in accordance with the shipping list.
5. Advise OWNER of inspection results.

3.2 INSTALLATION

A. Assembly and Installation:
1. Receive, unload, assemble, and connect equipment.
2. Assemble to manufacturer's recommendations.
3. Short all current transformer secondaries at terminal blocks in mechanism enclosure (unless directed otherwise by manufacturer's recommendations or relay test technician).
4. Make connections to external wiring in accordance with the Drawings, these Specifications, and manufacturer's recommendations (as required to permit checkout and testing of breaker).
5. Make adjustments recommended by Manufacturer.
6. Paint any scratched surfaces with touch-up paint.

B. Fill with Insulating SF_6 Gas:
1. Follow manufacturer's recommendations.
2. Schedule shipments of SF_6 gas.
3. Use procedures and equipment which ensure integrity of the insulating SF_6 gas.

3.3 FIELD QUALITY CONTROL

A. Coordinate with factory service representative so that he may be present during assembly and installation, filling with insulating SF_6 gas checkout and field testing, and placing in service.

B. Inspect Installed Breaker and Components (Checkout):
1. Satisfactory workmanship.
2. Conformance with Specifications and Drawings.
3. Correct nameplate information and ratings.
4. Proper alignment and fit.
5. Required grounding connections including frame, mechanism, and current transformers.
6. Tightness of bolting hardware.
7. Tightness of wiring terminals.
8. Tap setting and shorting of current transformers.
9. SF_6 gas pressure, where applicable.
10. Make functional check of all controls.
11. All inspections recommended by Vendor.
12. Make field tests (see below).

C. Furnish all labor, material, and equipment required for field tests.

D. Perform the following field tests:

1. Timing tests (ANSI C37.09-1979, Article 5.12).
2. Measure DC resistance of the power carrying circuit from terminal to terminal (use 100 ADC minimum).
3. Current transformers:
    a. Ratio test (use primary current injection).
    b. Polarity test.
    c. Megger between secondary leads (all phases tied together) and ground. Use 1000 V test voltage for 1 minute, or until reading remains constant for 15 seconds.
    d. Acceptable megger reading: 5 megohms, minimum.
4. Single-phase motors:
    a. Visual inspection.
    b. Megger motors with supply cables connected (but disconnected at source).
    c. Motor to be at ambient temperature.
    d. Use 500 V test voltage for 1 minute, or until reading remains constant for 15 seconds.
    e. Megger between phase and neutral conductor, tied together, and ground.
    f. Acceptable reading: 5 megohms, minimum.
    g. Verify satisfactory performance and rotation by running motor.
    h. Check lubrication.
5. Sensors and alarm/control contacts:
    a. Megger between leads and case (see manufacturer's instructions for test voltage).
6. Energize cabinet heaters and thermostat and verify operation.
7. Verify proper operation of manual trip.

E. For Acceptance: Pass all inspections and tests.

F. Records:
1. Statement that equipment has passed all inspections.
2. Megger readings versus time data, including converted values and ambient temperature at time of test.
3. Contact resistance values.
4. Results of timing tests.
5. Results of CT tests.
6. Results of all tests recommended by Vendor.

3.4 DUTIES OF SERVICE REPRESENTATIVE

A. Manufacturer's factory trained service representative shall perform services described within the following:
1. Service representative's time at site shall be as needed to complete the Work.
2. One trip to site shall be furnished.
3. Provide service representative's transportation and expenses.
4. Inspect the mechanical and electrical installation and certify the equipment has been installed in accordance with manufacturer's instructions and is ready for startup and initial operation.
5. Filling with insulating medium.
6. Instruct personnel designated by OWNER in operation and maintenance of equipment.

B. Service representative shall supervise the following:
1. Assembly and installation.
2. All inspections, adjustments and tests required by the manufacturer.
3. Field tests and checkout described herein.
4. Placing equipment in operation.

C. Testing equipment and procedures subject to approval and direction of factory service representative.

D. A written report shall be completed by the service representative following all successful testing before leaving the jobsite. Formal documentation six (6) certified copies must be received within ten (10) working days.

END OF SECTION

SECTION 33 77 39
HIGH VOLTAGE SURGE ARRESTER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. High Voltage Surge Arrestor.

B. Related Specification Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical: Common Work Results.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. Institute of Electronic and Electronics Engineers, Inc. (IEEE):
      a. Std 4, Standard for High-Voltage Testing Techniques.
      b. 693, Recommended Practices for Seismic Design of Substations.
      c. C57.19.00, Standard General Requirements and Test Procedures for Power Apparatus Bushings.
      d. C62.11 Standard for Metal-Oxide Surge Arresters for AC Power Circuits
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL).

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data:
      a. Provide submittal data for all products including subcomponents specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   2. Fabrication and/or layout Drawings.
      a. Outline Drawing including dimensions, weight and identification of all components and features.
      b. Nameplate Drawing.
   3. Certifications:
      a. NA
   4. Test reports

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Content of Operation and Maintenance Manual:
         1) Instruction and maintenance manual.
         2) Product technical data provided in the submittal.
         3) Outline drawing updated for as-built conditions.
         4) Nameplate Drawing updated for as-built conditions.
         5) Factory test report.
         6) Acceptance testing report.

C. Informational Submittals:
   1. Factory test report.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. ABB.
   2. Cooper.
   3. GE.
   4. Hitachi.
   5. Ohio Brass.
   6. Siemens.
   7. Or Equal

2.2 PERFORMANCE / DESIGN CRITERIA

A. General:
   1. High Voltage Surge Arrestor to be designed and constructed in accordance with:
      a. IEEE C62.11

B. Ratings and Configurations:
   1. Type: Outdoor/Indoor, Gapless Metal Oxide High Voltage Surge Arrestor.
   2. Mounting: self-supporting and shall have a mounting base of cast (ductile) iron, structural steel, or aluminum.
   3. Operation type and application: Station Class/Substation Equipment Surge Protection.

1. Insulator: Porcelain.
   2. System Configuration. Solidly Grounded
   3. Maximum System Voltage: 362 kV.
   4. Nominal System Voltage: 345 kV.
   5. Arrestor Rating Voltage rms: 276 kV
   6. MCOV (Line to Neutral) rms: 220 kV
   7. Frequency: 60 Hz.
   8. Basic Lightning Impulse level (BIL): 1300kV
   9. Connections:
      a. As indicated on the Drawings.
      b. Primary Bushings: NEMA 4 Hole

C. Components:
   1. Arrestor Body: The arrestor shall be a porcelain station class, metal top construction.
   2. Metal Components: All metal components exposed to weather and corrosion shall be zinc coated by the hot dip galvanizing process.
   3. Metal Oxide Disks: Gapless construction of metal oxide varistor elements.
   4. Pressure Relief Vents: Arrestors shall have appropriate pressure relief vents to act positively to vent gas in the event of an arrestor failure.
   5. Ground Lug: Arrestor shall be furnished with a ground lug installed (#2 – 250 kcmil Copper).
   6. Corona mitigation shall be furnished as required.
   7. Finish:
      a. Manufacturer's standard corrosion protection system in accordance with IEEE C57.13.
      b. Grey.
   8. Accessories: None

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: At a minimum, provide all routine tests as specified in IEEE C62.11.

2.4 MAINTENANCE MATERIALS

A. NA

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as detailed on the Drawings and in accordance with NFPA 70 and manufacturer's instructions.

B. Install Surge Arrestor per detail on the Drawings.

END OF SECTION