Electrical Performance Standard

This Document Defines or Describes Construction Design Standards
For Use At S&T/WPS Facilities

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SECTION 260513 - MEDIUM-VOLTAGE CABLES

1.1 SYSTEM DESCRIPTION

A. Quality Standards: IEEE C2 and NFPA 70.

1.2 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member Company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.3 COMPONENTS

A. System Description

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C2 and NFPA 70.
3. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

B. Cables:

1. Type: MV105.
2. Conductor: Copper.
3. Conductor Stranding: Compact round, concentric lay.
4. Strand Filling: Conductor interstices are filled with impermeable compound.
5. Conductor Insulation: Crosslinked polyethylene.

a. Voltage Rating: Confirm with local system.
b. Insulation Thickness: 133 percent.

6. Shielding: Copper tape.
7. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.
8. Cable Jacket: Chlorosulfonated polyethylene.

C. Connectors:

1. Copper-Conductor Connectors: Copper barrel crimped.

D. Solid Terminations:

a. Shielded-Cable Terminations: Class 1, modular kit, indoors, with stress-relief tube.

E. Separable insulated connectors with dead-break cable terminators.

F. Splice Kits: Combination tape and cold-shrink-rubber sleeve with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.

G. Medium Voltage Tapes

1. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.
2. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.
3. Insulating-putty, 125-mil (3.175-mm) elastic filler tape. Minimum 1-1/2 inches (38 mm) wide.

H. Arc-Proofing Materials

1. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
2. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.
3. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide.

I. Fault indicators: Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable

1.4 INSTALLATION

A. Install cables according to IEEE 576.

1.5 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing and inspecting agency to perform field tests and inspections, and to prepare test reports.

B. WARNING

1. Disconnect cable to be tested from switchgear, transformers, etc. at each end, so that voltage is applied only to cable length being tested. Properly clean ends of conductor. Use solvent recommended by cable manufacturer, if required

END OF SECTION 260513

Electrical Performance Standard

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SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.2 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

D. Conductor Insulation:

1. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
2. Type THHN and Type THWN-2: Comply with UL 83.
3. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
4. Type UF: Comply with UL 83 and UL 493.

E. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

1.3 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Aluminum, complying with ASTM B 800 and ASTM B 801.

D. Conductor Insulation:

1. Type XHHW-2: Comply with UL 44.

1.4 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

1.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper; Aluminum.
2. Type: Two hole with long barrels.

3. Termination: Compression.

1.6 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable which shall be extra-flexible, stranded.

1.7 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

F. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway; Mineral-insulated, metal-sheathed cable Type MI only where approved by owner.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway; Mineral-insulated, metal-sheathed cable, Type MI, only where approved by owner.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN/THWN-2, single conductors in raceway.

J. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

K. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway; Mineral-insulated, metal-sheathed cable, Type MI only where approved by owner.

L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, and strain relief device at terminations to suit application.

M. VFC Output Circuits: Type XHHW-2 in metal conduit.

1.8 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Copper conductors #10 AWG and smaller shall be terminated and spliced with wire nut connectors. The nylon self-insulated type shall be used to isolate the termination from other metal parts and equipment.

D. Copper conductors #8 AWG and larger shall be terminated, spliced, and tapped with color-keyed compression connectors. The manufacturers recommended tools and dies shall be used.

E. Copper cable lug connections #8 and larger to copper bus bar mains and branches shall use copper solderless connectors having either 2-bolt cast copper clamps or compression connectors, with manufacturer's recommended hexagonal dies and hydraulic compression tools.

1.9 FIELD QUALITY CONTROL

A. Perform each of the following visual and electrical tests:
1. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
2. Test bolted connections for high resistance using one of the following:
   a. A low-resistance ohmmeter.
   b. Calibrated torque wrench.
   c. Thermographic survey.
3. Inspect compression-applied connectors for correct cable match and indentation.
4. Inspect for correct identification.
5. Inspect cable jacket and condition.
6. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for one-minute duration.
7. Continuity test on each conductor and cable.
8. Uniform resistance of parallel conductors.

END OF SECTION 260519

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SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

1.1 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL with a field supervisor certified by BICSI as an RCDD.

1.2 COMPONENTS

A. Backboards: Plywood, fire-retardant treated.

B. Balanced Twisted Pair Cable:

1. 100 ohm, four pair, Category 6.
2. Plenum rated, riser rated and general purpose.

C. Balanced Twisted Pair Cable Hardware:

1. Connecting Blocks: 110-style IDC for Category 6.
2. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
3. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack.
4. Workstation Outlets: Two-port-connector assemblies mounted in multi-gang faceplate.
5. Faceplates: Plastic.

D. RS-485 Cable: Standard, Type CMG, Plenum rated, Type CMP, two twisted pairs, No. 22 AWG, stranded copper, unshielded.

E. Low-Voltage Control Cable:

1. Paired Cable: Copper, unshielded, twisted pair, No. 16 AWG, Type CMG; No. 16 AWG, plenum-rated, Type CMP.
2. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway.
3. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway.
4. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway.
5. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1.3 SOURCE QUALITY CONTROL

A. Factory test twisted pair cables according to TIA-568-C.2.

1.4 INSTALLATION

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

A. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Install 110-style IDC termination hardware unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

B. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.

D. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

A. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

1.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

END OF SECTION 260523

Electrical Performance Standard

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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

1.2 PRODUCTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Conductors:

1. Insulated Conductors: Copper wire or cable.
2. Bare Copper Conductors:

    a. Bonding cable.
    b. Bonding conductor.
    c. Bonding jumper.
    d. Tinned bonding jumper.

3. Grounding Bus: Predrilled rectangular copper bars with stand-off insulators.

D. Connectors:

1. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
3. Pipe Connectors: Clamp type, sized for pipe.
4. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
5. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

E. Grounding Electrodes:

1. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.
2. Chemical Electrodes: Copper tube charged with nonhazardous electrolytic chemical salts.

1.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.

1.1 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements

1.1 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

1.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

b. Perform tests by fall-of-potential method according to IEEE 81.

3. Report measured ground resistances that exceed the following values:

   a. Power and Lighting Equipment or System with Capacity 500 kVA and less: 10 ohms.
   b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
   c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
   d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
   e. Substations and Pad-Mounted Equipment: 5 ohms.
   f. Manhole Grounds: 10 ohms.

END OF SECTION 260526

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SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

1.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Consult structural engineer on safety factor to be specified in paragraph below, or delete and let applicable code determine strength. Retain below if strength that exceeds code requirements is desired.

E. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.2 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.3 PRODUCTS

A. Support, Anchorage, and Attachment Components:

1. Galvanized-steel or Stainless-steel slotted support systems with metallic coatings.
2. Aluminum slotted support systems with nonmetallic coatings.
3. Nonmetallic slotted support systems.
4. Raceways and cable supports.
5. Steel conduits and cable hangers, clamps, and associated accessories.
6. Support for non-armored conductors and cables in vertical conduit risers.
7. Structural steel for fabricated supports and restraints.
8. Mounting, Anchoring, and Attachment Components:

   a. Powder-actuated fasteners.

b. Mechanical-expansion anchors.
c. Concrete inserts.
d. Clamps for attachment to steel structural elements.
e. Steel springhead toggle bolts.
f. Threaded hanger rods.

B. Fabricated Metal Equipment Support Assemblies: Welded or bolted steel shapes.

1.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where it’s Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

1.2 SUPPORT INSTALLATION

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawing.

B. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

1.3 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete.

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SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.2 MATERIALS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Metal Conduits and Fittings:

1. GRC: Comply with ANSI C80.1 and UL 6.
2. ARC: Comply with ANSI C80.5 and UL 6A.
3. IMC: Comply with ANSI C80.6 and UL 1242.
4. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
5. Comply with NEMA RN 1.
6. Coating Thickness: 0.040 inch (1 mm), minimum.
7. EMT: Comply with ANSI C80.3 and UL 797.
8. FMC: Comply with UL 1; zinc-coated steel or aluminum.
9. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
10. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
11. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
12. Fittings for EMT:
    a. Material: Steel.
    b. Type: compression.
    c. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions were installed and including flexible external bonding jumper.
    d. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
13. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

C. Nonmetallic Conduit and Fittings:

1. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ENT: Comply with NEMA TC 13 and UL 1653.
3. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.
5. Rigid HDPE: Comply with UL 651A.
6. Continuous HDPE: Comply with UL 651B.
7. Coinable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.
8. RTRC: Comply with UL 1684A and NEMA TC 14.
9. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
10. Fittings for LFNC: Comply with UL 514B.
11. Solvents and Adhesives: As recommended by conduit manufacturer.

D. Metal Wireways and Auxiliary Gutters: Sheet metal with hinged covers.

E. Nonmetallic Wireways and Auxiliary Gutters: PVC plastic.

F. Surface Metal Raceways: Metal, galvanized steel, with Snap-On covers.

G. Surface Nonmetallic Raceways: Two- or three-piece, rigid PVC.

H. Tele-Power Poles: Galvanized steel with ivory baked-enamel finish.

I. Boxes, Enclosures, and Cabinets:

1. Metal Outlet and Device Boxes: Ferrous alloy.
2. Nonmetallic outlet and device boxes.
3. Metal Floor Boxes: Cast metal or Sheet metal, fully adjustable.
4. Nonmetallic Floor Boxes: Non-adjustable, round or rectangular.
5. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. (23 kg).
6. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb. (32 kg).
7. Small sheet metal pull and junction boxes.
8. Cast-metal access, pull, and junction boxes.
9. Box extensions.
10. Gangable boxes are prohibited.
11. Hinged-Cover Enclosures: Metal or Nonmetallic.
12. Cabinets: Galvanized steel.

J. Handholes and Boxes for Exterior Underground Wiring: Polymer concrete with polymer-concrete or Fiberglass with polymer-concrete frame and cover, prototype tested for compliance with SCTE 77.

1. Configuration: Integral closed bottom.

2. Weatherproof cover.
3. Cover Legend: Molded lettering, as indicated for each service.

1.3 RACEWAY APPLICATION

A. Outdoors:

1. Exposed: GRC.
2. Concealed, Aboveground: GRC.
3. Underground: RNC, Type EPC-80-PVC, direct buried.
4. Connection to Vibrating Equipment: LFMC.
5. Boxes and Enclosures, Aboveground: Type 3R.

B. Indoors:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Damage: GRC.
4. Concealed: EMT.
5. Connection to Vibrating Equipment: FMC, except LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: Type 1, except Type 4 stainless steel in commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Threaded rigid steel conduit fittings.
2. PVC Externally Coated, Rigid Steel Conduits: Fittings listed for use with this type of conduit.
3. EMT: Compression, steel fittings.
4. Flexible Conduit: Fittings listed for use with flexible conduit.

1.4 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

END OF SECTION 260533

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.2 MATERIALS

A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.
   1. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.

B. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts; with Type 316 stainless-steel splice-plate fasteners, bolts, and screws.

C. Cable Trays, Fittings, and Accessories: Stainless steel, Type 316, complying with NEMA VE 1.

D. Cable Trays, Fittings, and Accessories: Fiberglass, complying with NEMA FG 1 and UL 568. Splice-plate fasteners, bolts, and screws shall be fiberglass-encapsulated stainless steel. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.

E. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

   1. Center-hanger supports may be used only when specifically indicated.

1.3 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Covers: Solid type of same materials and finishes as cable tray.

C. Barrier Strips: Same materials and finishes as cable tray.

D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

1.4 WARNING SIGNS

A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."

1.5 SOURCE QUALITY CONTROL

A. Tested according to NEMA VE 1.

1.6 CONNECTIONS

A. Ground cable trays according to manufacturer's written instructions.

B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

1.7 INSTALLATION

A. Install cable tray and support systems according to NEMA VE 2.

B. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.

C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Fasten cable tray supports to building structure.

E. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb. (90 kg). Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."

F. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

G. Install cables only when cable tray installation has been completed and inspected.

H. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

I. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

1.8 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

END OF SECTION 260536

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 260539 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 884.

C. Comply with NFPA 70.

1.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Jacks, Receptacles, and Fittings:

1. Comply with Section 262726 "Wiring Devices" for power outlets, faceplates, and connectors.
2. Coordinate with Corning communications vendor for communication outlets, faceplates, and connectors.

1.3 FLAT-TOP, STEEL UNDERFLOOR RACEWAYS

A. Description: Steel, rectangular, flat-top, single-channel raceways with premanufactured inserts

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; Schneider Electric.
2. Thomas & Betts Corporation; Steel City Division.
3. Walker Systems, Inc.; a Wiremold company.

C. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

D. Material: One-piece, continuous weld, minimum 0.0598-inch- (1.5-mm-) thick steel, with corrosion-resistant coating inside and out after welding.

E. Cross-Section Shape: Rectangular, with rounded corners.

F. Number of Longitudinal Channels: Two, separated by steel wall(s).

G. Number of Levels: One.

H. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.

I. Service Raceways: Fitted with preset inserts.

1. Nominal Multichannel Underfloor Raceway Dimensions:

   a. Depth: 1-3/8 inches (35 mm).
   b. Overall Width: 10 inches (250 mm).
   c. Power Service Channel Width: 3-1/2 inches (88 mm).
   d. Communication Service Channel Width: 6-1/2 inches (163 mm).

2. Nominal Single-Channel Underfloor Raceway Dimensions:

   a. Depth: 1-1/2 inches (38 mm).
   b. Power Service Raceway Width: 3-1/4 inches (81 mm).
   c. Communication Service Raceway Width: 3-1/4 inches (81 mm).
   d. Number of Single-Channel Raceways per Run: Two, unless otherwise indicated.

3. Preset Inserts: Rectangular.

   a. Spacing: 12 inches (300 mm) oc.
   b. Size: Rectangular dimensions as required to accommodate mounting and connection of flush- and surface-mounted, single- and multiple-outlet service fittings or to connect to wiring extensions for feeding wall outlets for power and communications Insert system.
   c. Size: 2 inches (50 mm) in diameter.
   d. Equip each insert with a disposable cover, and select insert height so cover is 1/8 inch (3 mm) below surface of concrete.
   e. Arrange insert for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to flush or surface outlet-mounting connector, jack, and receptacle devices.

J. Header Raceways: Single-channel, without preset inserts (blank raceway).

1. Nominal Raceway Dimensions:

   a. Depth: Same as service raceways.
   b. Power Header Raceway Width: 3-1/2 inches (88 mm).
   c. Communication Header Raceway Width: 3-1/2 inches (88 mm).

2. Arrangement: In same plane as service raceways.
3. Connections: Arranged to connect with service raceways at single-level junction boxes.

1.4 FLUSH, FLAT-TOP UNDERFLOOR RACEWAYS

A. Description: Single or multichannel underfloor raceways installed on floor slab with top of raceway flush with concrete topping added hereafter, and then covered with finish material.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; Schneider Electric.
2. Thomas & Betts Corporation; Steel City Division

C. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

D. Description:

1. Material: Steel.
2. Cross-Section Shape: Rectangular, single channel and multichannel, separated by steel wall(s).
3. Listed and labeled for installation with top flush with concrete floor.
4. Number of Levels: One.

E. Service Raceways: Fitted with preset inserts.

1. Number of Longitudinal Channels per Multichannel Raceway: Two.
2. Number of Single-Channel Raceways per Run: One unless otherwise indicated.
3. Nominal Channel Dimensions: 3 inches (75 mm) wide by 1-1/4 inches (31 mm) deep.
4. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.

   a. Spacing: 12 inches (300 mm) oc., full length of each service raceway.
   b. Arrangement: Stagger locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
   c. Size: 1-5/8-inch (41-mm) diameter.

F. Trench Duct Cross-under: Fitting attached to underside of trench duct.

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: Offset by depth of trench duct.
3. Connections: Arranged to connect trench duct to flush duct through factory-cut, grommet openings.

G. Header Raceways: Raceways same as service raceways, except without preset inserts (blank raceway).

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: In same plane as service raceways.

H. Connections: Arranged to connect with service raceways at junction boxes

1.5 CELLULAR METAL UNDERFLOOR RACEWAYS

A. Description: Multichannel, cellular, underfloor service raceways installed on floor slab with top of raceway flush concrete topping added hereafter, and then covered with finish material.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. HH Robertson; Division of CENTRIA.
2. Walker Systems, Inc.; a Wiremold company.

C. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

D. Material: Galvanized-steel sheet, ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230) minimum, G60 (Z180) zinc coating.

E. Material: Galvanized- and shop-primed steel sheet, ASTM A 653/A 653M, Structural Steel (SS), Grade 33 (230), G60 (Z180) zinc coating; with underside surface cleaned, pretreated, and primed with manufacturer's standard gray baked-on, rust-inhibitive primer.

F. Number of Longitudinal Cells: Three, separated by steel walls.

G. Nominal Dimensions of Cells:

1. Overall Depth: 1-1/4 inches (31 mm) unless otherwise indicated.
2. Cross-Sectional Area of Cells: Power cells: 5-1/2 sq. in. (34.4 sq. cm); communication system cells: 16 sq. in. (100 sq. cm).

H. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.

I. Service Raceways: Fitted with preset inserts.

1. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical outlet access to each cell of each raceway designated for service raceway use. Inserts shall be provided throughout the entire length of each such raceway.

   a. Spacing: 12 inches (300 mm) oc.
   b. Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-outlet service fitting.
   c. Include mounting and connecting provisions for a surface, single- or multiple-outlet service fitting.
   d. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.

e. Equip each insert with a disposable cover plate arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable top.

J. Header Assembly: A junction box and raceway arrangement positioned to feed wires and cables to service raceways.

1. Three-compartment junction box connecting blank, multi-cell cellular header raceway (no inserts) with cellular service raceways at right angles to header raceway.
2. Cellular header raceway shall be made of the same material and have the same nominal dimensions as service raceways.
3. Provide capability for service raceways to be run in both perpendicular directions at the intersection with header raceway.

1.6 TRENCH-TYPE UNDERFLOOR RACEWAYS

A. Description: Trench-type raceways used as header or feeder raceways to serve service raceways.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. HH Robertson; Division of CENTRIA.
2. Square D; Schneider Electric.
3. Thomas & Betts Corporation; Steel City Division.

C. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

D. Trench: Steel, shop or factory welded and fabricated to indicate sizes. Include the following features:

1. Slab Depth Adjustment: Minimum of minus 1/8 inch (3 mm) to plus 5/8 inch (17 mm) before and during concrete placement.
2. Cover Supports: Height adjustable, with leveling screws to rigidly support cover assembly.
3. Screed Strip: Extruded aluminum along both edges at proper elevation without requiring shim material.
4. Trim Strip: Select to accommodate floor finish material.
5. Partitions: Arranged to separate channels and isolate wiring of different systems.
6. Grommet openings in active floor cells or service raceways.
7. Manufacturer's standard corrosion-resistant finish, applied after fabrication.

E. Cover Plates: Removable, steel plates, 1/4 inch (6 mm) thick, each weighing 60 lb. (27 kg) or less with full gasket attached to side units. Fabricate intermediate supports to limit unsupported spans to 15 inches (375 mm) or less. Fabricate covers with appropriate depth recess to receive indicated floor finish.

1.7 ELECTRICAL CONNECTION COMPONENTS FOR CELLULAR FLOOR DECKS

A. Electrical Connection Components for Cellular Steel Floor Deck: Rectangular preset inserts.

B. Electrical Connection Components for Cellular Concrete Floor Deck: Afterset inserts.

C. Preset Inserts: Rectangular metal-housing assemblies.

1. Spacing: 24 inches (600 mm) oc.
2. Disposable cover.
3. Flush, recessed, or surface service fitting; single, double, or triple outlet.
4. Provisions for a wiring-extension service fitting to feed wall outlets.

1.8 ELECTRICAL CONNECTION COMPONENTS FOR PRECAST CELLULAR CONCRETE FLOOR DECK

A. Afterset Inserts: Round metal-nipple assembly with internal and external threading.

1. Provide wiring path from cell to power and communication wall and ceiling outlets.
2. Provide wiring path from cell to header raceway.

1.9 SUPPORTS, RACEWAY FITTINGS, AND HARDWARE

A. Source Limitations: Obtain underfloor raceway supports, fittings, and hardware components for each system through single source from single manufacturer.

B. Supports, fittings, and hardware shall be compatible with raceway and outlet system and shall be listed for use with raceway systems and components delivered.

C. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.

D. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.

1.10 JUNCTION BOXES

A. Description: Raceway manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:

1. Mounting brackets.
2. Escutcheons and holders to accommodate surrounding floor covering.
3. Means for leveling and height adjustment more than 3/8 inch (10 mm) before and after concrete is placed.

4. Boxes shall withstand a minimum 300-lb (136-kg) concentrated load. Internal supports shall be provided as needed to meet this requirement.
5. All boxes shall provide 2-inch- (50-mm-) minimum bend radius for data and communication cables.
6. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
7. Covers shall have appropriate depth recess to receive specific floor finish material.
8. Partitions to separate wiring of different systems.

1.11 SERVICE FITTINGS/ACTIVATIONS

A. Source Limitations: Obtain underfloor raceway service fittings and hardware for each system through single source from single manufacturer.

B. Exposed Parts Finish: Brushed aluminum.

C. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.

1. Connector, Jack, and Receptacle Devices: Single modular type.
2. Power Receptacle Outlet: Suitable for 20-A, 120-V device.

D. Flush, Single- or Multiple-System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.

1. Connector, Jack, and Receptacle Devices: Modular type.
2. Power Receptacle Rating: 20 A, 120 V unless otherwise indicated.
3. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts. Include device plates for indicated systems and provisions for receptacles, jacks, and connectors. Include hinged flush covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies.

   a. Duplex receptacle.
   b. Duplex data jacks.
   c. Double duplex receptacles.
   d. Duplex receptacle and duplex data jacks.
   e. Fiber-optic cable connector.

E. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.

1. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
2. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
3. Communication-outlet, double-faced, surface-mounted unit.

a. Include bushed openings on both sides; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
b. Include provisions for modular dual fiber-optic connector assembly on both sides.
c. Include provisions for modular dual jack-connector assembly, rated for Category 6 on both sides.

4. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
5. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.

a. Communication Side: Include bushed opening; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
b. Communication Side: Include provisions for modular dual fiber-optic connector assembly.
c. Communication Side: Include provisions for modular dual jack-connector assembly, rated for Category 6.

6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and shall include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush covers, recessed to suit floor finish material.

a. Duplex convenience receptacle.
b. Duplex data outlets.
c. Double duplex convenience receptacles.
d. Duplex convenience receptacle and duplex data outlets.
e. Double duplex data outlets.
f. Duplex fiber-optic communication connector.

F. Wiring-Extension Service Fittings: Arrangement of brackets and mountings to support and provide access to wiring or cabling of a cell, and to connect the cable or raceway that extends the system to an individual wall outlet.

1.12 INSTALLATION

A. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to floor supports.

B. Maintain arrangement of conductor services throughout the raceway system.

C. Install a concrete mud slab for support of cellular metal, flush duct, or trench duct raceway. Construct mud slab with wire mesh in the top 1 inch (25 mm) of concrete.

D. Install a vapor barrier between the cellular metal raceway and a substrate in contact with earth.

E. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Fasten supports securely at ends and at intervals not to exceed 60 inches (1500 mm), to prevent movement during concrete pour.

F. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.

G. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of the Work.

H. Install preset inserts per manufacturer's instructions.

I. Adjust supports to maintain a 1/8- to 3/8-inch (3.0- to 10-mm) finished concrete cover over preset inserts.

J. Remove burrs, sharp edges, dents, and mechanical defects.

K. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.

L. Install expansion fittings with suitable bonding jumper where raceways cross building expansion joints.

M. Bond underfloor raceway components to create a continuous bonding path.

N. Seal raceways, cells, junction boxes, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Tape joints or seal with compound, as recommended in writing by underfloor raceway manufacturer.

O. Afterset Inserts: Cut, whole saw, and drill slab and raceways to allow for installation at locations indicated on plans.

P. Wiring shall comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and NFPA 70 requirements for wet locations.

1. Install wiring from outlet insert toward junction boxes, then to termination at panel.
2. Splices: All splices and taps shall be made in junction boxes. No splices or taps shall be made in raceways or outlet inserts.

1.13 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform visual inspection of interior of each junction box to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
2. Prior to and after concrete pour, perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.

a. Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.

3. Comply with NETA Acceptance Testing Specification about safety, suitability of test equipment, test instrument calibration, and test report and records.

END OF SECTION 260539

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities

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SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

1.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Quality Standard: ANSI C2.

1.2 COMPONENTS

A. Conduits and fittings.

1. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
2. RNC: NEMA TC 2, Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

B. Rigid nonmetallic duct.

1. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.

C. Duct accessories.

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

   a. Color: Red dye added to concrete during batching.
   b. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

D. Precast concrete handholes and boxes.

1. Comply with ASTM C 858 for design and manufacturing processes.

2. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
3. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

b. Cover Legend: Molded lettering, as indicated for each service.
c. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
d. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
e. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
h. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

E. Handholes and Boxes Other than Precast Concrete:

1. Polymer concrete handholes and boxes with polymer concrete cover.
2. Fiberglass handholes and boxes with polymer concrete frame and cover.
3. Fiberglass handholes and boxes with covers of polymer concrete.
4. High-density plastic boxes with covers of polymer concrete.

F. Precast concrete manholes.

1. Comply with ASTM C 858.
2. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.
4. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
5. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

   a. Type and size shall match fittings to duct or conduit to be terminated.
   b. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
6. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.
7. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.
8. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

G. Utility Structure Accessories:

1. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

2. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 26 inches (660 mm).

a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

3. Cover Legend: Cast in. Selected to suit system.

   a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

4. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

   a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
   b. Seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.

5. Most manufacturers' standard precast units have sump consisting of depression in floor only and no frame or grate. 12-1/2-inch- (313-mm-) diameter, 4-inch- (100-mm-) deep thermoplastic sump is also available for casting into the manhole floor.

6. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

7. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

   a. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

8. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.

9. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

   a. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.

10. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.

    a. Tested Ultimate Pullout Strength: 12,000 lb. (53 kN) minimum.

11. Ground Rod Sleeve: 3-inch (75-mm), PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

12. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

14. Cable Rack Assembly: Steel, hot-rolled galvanized, except insulators.

    a. Stanchions: T-section or channel; 2-1/4-inch (56-mm) nominal size; punched with 14 holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.

    b. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.

    c. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

15. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

    a. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of nine holes for arm attachment.

    b. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

16. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

18. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.

19. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). One required.

20. Cover Hooks: Heavy duty, designed for lifts 60 lb. (270 N) and greater. Two required.

1.3 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

1.4 INSTALLATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

1.5 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

C. Underground Ducts Crossing Driveways Roadways: Type EPC-80 PVC RNC, encased in reinforced concrete.

D. Stub-ups: Concrete-encased GRC.

1.6 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.

3. Units in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

C. Concrete-Encased Ducts: Support ducts on duct separators.

1.7 DUCT INSTALLATION

A. Install ducts according to NEMA TCB 2.

END OF SECTION 260543

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Sleeves and Sleeve Seals for Electrical Raceways and Cabling**
Document Number	**26 05 44**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
Document Owner	**Facilities Electrical Engineering**
Approvals	**Document Owner, Documentation Administrator**
Key Words	**Identification, Warning tape, Warning labels, Miscellaneous**

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Rev #	Revision Originator	Revision Date	Sections Revised	Summary of Revisions made	
1	D. Luchaco	07/19	--	Standards Review	

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

1.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

1.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

1.3 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

1.4 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

1.5 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

1.6 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

1.7 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards
For Use At S&T/WPS Facilities

Document Title	**Identification for Electrical Systems**
Document Number	**26 05 53**
Document Type	**Performance Standard**
Original Author and Date	**Dean Luchaco 11/9/2018**
Document Owner	**Facilities Electrical Engineering**
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Key Words	**Identification, Warning tape, Warning labels, Miscellaneous**

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Rev #	Revision Originator	Revision Date	Sections Revised	Summary of Revisions made	
1	Eddie Nichols	1/19/10	3.1.1	Removed the labeling identification for conduits	
2			1.1B	Reference to 260573 – Overcurrent Protective Device Coordination Study	
3			1.2.B	Add arc flash labeling	
4			2.9	Arc Flash Labeling Requirements	
5			3.2.I	Additional tabware requirements	
6	Laura Masters	6/1/12	All	Removing excess white space, spell check, corrected pg numbering starting on pg 3 (involved redoing headers & section breaks on certain pgs)	
6	Laura Masters	6/4/12	All	Changing allmeasuement blue & red fonts to black	
7	Dean Luchaco	9/28/12	3.2.J.5	Added GFCI feed information	
8	Dean Luchaco	10/18/13	2.9	Arc flash labeling requirements are revised.	
			1.2.B, C	Guideline information added	
			1.6	Add General Concepts information	
			1.7	Add Definitions	
			2.7.A.10	Label information added	
			2.8	Label Maker and Label charts added	
			3.2.J	Tabware Device/Building Codes chart revised	
			3.3.A	Panel Labeling Examples Revised	
			3.3.B	Bus Duct Labeling Revised	
			2.8	Label maker and charts removed	
			3.2.I	“HIGH-LEG” Identifacation Added	
			3.2.J	Tabware Number Nection Revised	
			3.3	Panel Labeling Section Revised	
9	Dean Luchaco	2/20/13	3.3A	Panel Name Label Size Change (1” Width – 2” Width Label)	
10			1.3 A, B, C	Revised ‘Submittals’ to ‘Action Submittals’	
			2.1	Added ‘ Performance Requirements’	
11	Dan Loucks	4/27/16	2.8 A	Changed UPS only backed label colors to orange.	
12	Dean Luchaco	11/9/2018		Removed tabware references, updated UPS/Gen label colors	
13	Dean Luchaco	07/19	--	Standards Review	

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Refer to Section 260573, "Overcurrent Protective Device Coordination Study", for information regarding labeling requirements of equipment for arc flash hazard ratings.

1.2 SUMMARY

A. This Section includes the following:

1. Identification for raceway and metal-clad cable.
2. Identification for conductors.
3. Identification for power and control cable.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.
9. Equipment labels for arc flash hazard rating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70. Specific Articles include, but are not limited to:

1. 110.22 Identification of disconnecting means.
2. 215.8 Identifying conductor with the higher voltage to ground.
3. 230.56 Service conductor with the higher voltage to ground.
4. 230.70(B) Marking.
5. 408.13 General.
6. 620.51(D) Identification and signs.
7. 504.80 Identification.
8. 408.4 Circuit directory.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.45.

D. Comply with ANSI 1910.303 (f), C2 and with Z535.4 for safety signs and labels.

E. Comply with Corning IWMS Equipment Identification requirements.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

1.6 GENERAL CONCEPTS

A. When new equipment is installed, modified or relocated, all equipment and the associated infrastructure to that equipment will be labeled in accordance with the expectations outlined in this document. If existing equipment or infrastructure labeling is found to be out of compliance with these expectations, it is the responsibility of the Facilities Trades to correct any issues.(Project Manager, Trades Planner)

B. It is not the intent of this document to have employees enter into high voltage areas, electrical panels, or any other potentially dangerous area to determine compliance. Only those employees who are qualified (i.e. an electrician) are capable of entering into areas, for example, where live circuits (50 Volts or greater) are exposed. If there is any question about the ability of an employee to access a certain area to determine compliance, please contact the Safety Department, or have a qualified maintenance person make the determination.

1.7 DEFINITIONS

A. Authorized Employee: An employee who has successfully completed the "Lockout/Tagout Authorized" training class
B. Label: A permanent label (yellow, orange or red) with black lettering meeting the requirements as indicated in Section 2.7.10. Life safety applications use white background with red lettering where additional labeling is required as described in section 3.1.K.
C. IWMS: A unique number following the guidelines set forth in this document, determined by the IWMS Administrator, and described in document WPS-20144, titled *SP Level III-IWMS Equipment Number Request/ Removal/ Rename/ Reactive Work Instruction*. The IWMS number contains (in order) (e.i.: SW-PR-517).

1. Electrical component abbreviation
2. Building code
3. Sequential identification number
4. All electrical distribution systems and electrical components indicated on page 15 of this document, requires an IWMS number to be displayed in the field and documented in the record drawing package.

D. Qualified: An employee who has been electrically trained to the hazards of a piece of equipment, under the direct guidance of another electrically qualified individual (i.e. electrician).

E. Project Leader: This is the individual who is responsible for all aspects of the project from beginning to end. In the case of *Routine* work this is the trades planner or project manager. In the case of a minor or major project, this is the project leader assigned to that project. It is the Project Leaders responsibility to assure that all tradesman, contractors, and engineering firms are adhering to this labeling standard. Any labeling determined to be out of compliance with these standards shall be determined and resolved by the system owner.

F. General Contractor: Hired by a Project Manager to oversee all/or part of the electrical construction. Responsible for delivering Issued for Construction Drawings to subcontractors, collecting field mark-ups (redlines) (as-builts) and field verify all labeling requirements have been met so Engineering Firm (or Project Manager) can create electronic record drawings.

G. Contractors (Sub): Hired by Project Manager and/or General Contractors to perform all or part of the actual electrical construction. Responsible for receiving Issued for Construction Drawings from General Contractors(s), creating field mark-ups (redlines) (as-builts) and field verifying all labeling requirements have been met so Engineering Firm or Project Managers can create and deliver record drawings to the system owner.

H. Corning Inc. Tradesmen: Hired by Project Manager or by Customer (x-2700 Routine work order) to perform all/part of the actual electrical construction. Responsible for receiving Issued for Construction drawings from Project Planner or Project Manager, collecting field mark-ups (redlines) (as-builts) and field verifying all labeling meets labeling standards. Field mark-ups (redlines) are returned to Project Planner or Project Manager so record drawings can be created by the system owner (x-2700) or engineering firm (project).

I. System Owner: The system owner is the "Owner" of Workplace Services electrical systems. Compliance with the Electrical Identification Standard, 26 05 53 is determined and resolved by the System Owner.

J. Project Planner: Responsible for overseeing all/part of the electrical construction. Delivers Issued for Construction drawings to Tradesmen, collects field mark-ups (redlines) (as-builts) and field verifies that all labeling meets the labeling standards, so system owner or Project Manager can create record drawings.

K. Engineering Firm: Engineering firms are responsible for generating (Contact IWMS Administrator) required IWMS numbers and recording these numbers on the applicable drawings prior to issuing them for construction. Engineering firms are also responsible at the direction of the Project Manager, for delivering Issued for Construction drawings to subcontractors, collecting field mark-ups (redlines) (as-builts). The firm shall deliver a complete set of record drawings to the Project Manager (electronically), with all applicable IWMS numbers indicated on the drawings.

L. Feed Information: A detailed description identifying the electrical distribution system and associated electrical components used to supply power to that piece of equipment/component. (i.e. Supply: 1BD2.5E SW-PR-123 VIA. SW-PR-517).

M. Electrical Component: Used to switch, control or transfer power to/from an electrical distribution system or used to isolate electrical power serving facility or process equipment (i.e. SW-PR-123). Refer to Section 3.2.J for specific examples.

N. Electrical Distribution Systems: Systems supply power throughout the facility beginning at the receiving station, through substation and end at the panel level. This shall include, but not limited to systems that supply power to other electrical distribution system or supply power directly to process and/or facility equipment.

O. Record Drawing: Documented changes that occurred as a result of an electrical installation or modification. Applicable IWMS numbers and field verification of labeling are included within the documentation per specification in these standards.

P. Equipment: Any piece of equipment ("new" or "old") being relocated, modified or installed. This includes equipment that is moved within a lab if the electrical source/circuits have been changed from the original installation or labeling has been omitted or inconsistent with these standards set forth in this document.

Q. Infrastructure Systems: A system that has or displays the following characteristics:

A. Multiple Users
B. Remains as part of the facility if or when a process or project leaves
C. Budgeting for the system is covered in the rent
D. Site-wide impact

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ANSI/ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Color for Printed Legend:
1. Power Raceways Carrying Circuits at 600V or less: Black Letters on a YELLOW field
2. Power Raceways Carrying Circuits at more than 600V:
    A. Black letters on an orange field.
    B. Legend: “DANGER CONCEALED HIGH VOLTAGE WIRING” with 3 inch (75 mm) high letters on 20 inch (500 mm) centers.
3. Fire Alarm Circuits: Red letters on natural field.
4. Legend: Indicate system or service and voltage, if applicable.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

2.3 CONDUCTOR AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

B. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape, not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

2.4 FLOOR MARKING TAPE. Round circle in front of panels

A. Yellow background with black stripe 2 inch (50 mm) wide, 5 mil (0.125 mm) pressure-sensitive vinyl tape shall be used to identify working clearances around electrical equipment.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape
1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line

B. Tape:
1. Printing on tape shall be permanent and not be damaged by burial.
2. Tape material shall be chemically inert and shall not be subject to degradation when exposed to acids, alkalis, and destructive substances found in soils.

C. Color and Printing:
1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscription for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.6 WARNING LABELS AND SIGNS

A. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

B. Warning label and sign shall include, but are not limited to, the following legends:

Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

1. Workspace Clearance Warning:

A. Refer to OSHA Standard 1926.403(i) (1) (i) for clearance requirements.
B. Coordinate final label designation with Corning Facilities.

2.7 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face.

2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

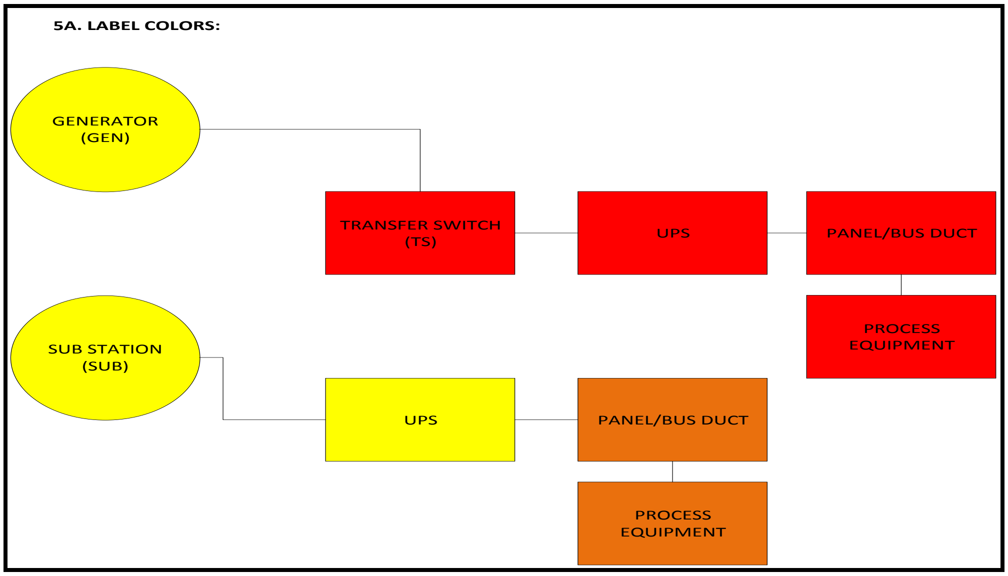
2.8 EQUIPMENT IDENTIFICATION LABELS

A. All labels shall be:

1. Water, dirt and oil resistant/repellent.
2. Acid and solvent resistant.
3. High tensile tearing strength and scratch resistant.
4. Self-adhering.
5. Color coded to coincide with the panel/bus types and associated equipment fed downstream as indicated below:

Panel/Bus Type	Label Color(s)*	Lettering Color
Utility Power Only	Yellow	Black
Generator & Utility Power	Red	Black
UPS & Utility Power	Orange	Black
UPS & Generator & Utility Power	Red	Black

* NOTE: Both the IWMS number label and the panel/bus feed label for all generator backed power shall be red labels with black lettering. All labeling downstream from “generator backed up” power source shall be red with black letters. All labeling downstream from “UPS only backed” power source shall be orange with black lettering. All labeling downstream from a “Generator backed UPS” power source shall remain red with black lettering. The intent of this is to clearly identify circuits fed from a “UPS ONLY” with an orange label and black lettering. This includes all bus switches, transformers, local disconnects, receptacles and process equipment feed information. All panels, bus ducts, or equipment NOT backed up by a secondary power source shall remain yellow and black. Refer to Section 5A chart below.



6. Sufficient durability to withstand the environment involved.

7. Comply with ANSI 1910.303(f).

8. Not less than 4 mil thick.

9. Displayed according to the guidelines for that infrastructure system with respect to content and placement as illustrated on the examples illustrated at the end of this specification section.

10. Yellow, Orange or Red background with black letters to coincide with the type of electrical distribution system and all associated electrical components fed downstream as described:

    A YELLOW: All electrical distribution systems and associated electrical components that are NOT "*backed up"* by a secondary power source (i.e. Generator/UPS) shall be identified by displaying both the IWMS number (if required) and the associated feed information using labels with YELLOW background and black lettering. This includes all labeling downstream of the electrical distribution systems or components that are not backed up by any other secondary power source.

    B RED: All electrical distribution system and associated electrical components that are *"backed up*" by a generator power source shall be identified by displaying both the IWMS number, if required, and their associated feed information using labels with RED background and black lettering. It also includes all labeling downstream of the electrical distribution systems or components that are backed up by a secondary power source. This includes all distribution systems that are designated as "Standby" and/or "Life Safety" (Section 3.1.1.2 for definitions). For clarification if a UPS is backed up by a generator, both the generator and UPS are identified by a label with

RED background since both the supply and feed side of the UPS could remain *"powered on"* in the event of a power failure.

C. ORANGE: All stand alone UPS systems that are NOT "backed up" by a generator shall be identified by displaying both the IWMS number, if required, and their associated feed information using labels with an ORANGE background with BLACK lettering. The feed side of the UPS will remain *"off"* during a power failure and therefore will retain a label with YELLOW background with BLACK lettering. Refer to illustration in section 5A. If a UPS is backed up by a generator, the UPS is identified by RED label with BLACK lettering since both the supply and feed side of the UPS could remain "powered on" in the event of a power failure.

NOTE: The only acceptable backgrounds for labeling (IWMS numbers and Feed Information) are RED, ORANGE and YELLOW. Lettering is to be black or red with an acceptable font that can be seen at a minimum of 10 feet. All other labeling colors or combinations to be corrected at the direction of the System Owner, Trades Planner, or Project Manager. The sole intent of distinguishing generator backup sources with RED labels, UPS ONLY backed sources with ORANGE labels and stand-alone (not backed up) with YELLOW labels is ONLY for the identification of the potential hazard of live circuits during a power outage. Refer to section3.1.K for proper identification of all Life Safety, Emergency and Legally Required

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch (5 mm)
2. Tensile Strength: 50 lb. (22.6 kg), minimum.
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.

C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

3.0 EQUIPMENT LABELS FOR ARC FLASH HAZARD RATING

D. All arc flash labels are furnished by Workplace Services (WPS) electrical engineering supervisor.

PART 3 - EXECUTION

3.1 APPLICATION

A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and are 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches (50 mm) high, with self-adhesive vinyl labels. Repeat legend at 10-foot (3-m) maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 90 A: Identify with orange self-adhesive vinyl label.

D. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:

1. Fire Alarm System: Red.
2. Fire-Suppression Supervisory and Control System: Red and yellow.
3. Combined Fire Alarm and Security System: Red and blue.
4. Security System: Blue and yellow.
5. Mechanical and Electrical Supervisory System: Green and blue.
6. Telecommunication System: Green and yellow.
7. Control Wiring: Green and red.

E. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use write-on tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

F. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with project drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

I. Warning Labels for indoor cabinets, boxes, and enclosures for power and lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:

    A. Power transfer switches.
    B. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

J. Instruction Signs:

1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch (10-mm) high letters for emergency instructions at equipment used for power transfer and/or load shedding.

K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

    A. Indoor Equipment: Self-adhesive, pre-printed, multi-color, pressure sensitive adhesive label**.** Refer to the sample labeling diagrams for the various electrical equipment included at the end of this specification section. Examples provide the content and format for equipment labeling.
    B. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
    C. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

D. Standby/Life Safety Modifiers:

1) Electrical distribution equipment which are designated as standby ("SB") and life safety ("LS") shall be labeled to clearly identify there source and use. This includes but is not limited to sources such as bus ducts, panels, switchboards, and motor control centers.

2) Apply a white label with red lettering on electrical sources that are deemed life safety.

THIS ELECTRICAL SOURCE CONTAINS: LIFE SAFETY, EMERGENCY AND/OR LEGALLY REQUIRED CIRCUITS.

3) Apply a white label with red lettering on all electrical equipment which is supplied from a life safety, emergency, or legally required power source to read:

THIS COMPONENT IS PART OF A LIFE SAFETY, EMERGENCY AND/OR LEGALLY REQUIRED CIRCUIT.

2. Equipment to Be Labeled:

A. Panelboards, electrical cabinets, and enclosures.
B. Access doors and panels for concealed electrical items.
C. Electrical switchgear and switchboards.
D. Transformers.
E. Electrical substations.
F. Emergency system boxes and enclosures.
G. Motor-control centers.
H. Disconnect switches.
I. Enclosed circuit breakers.
J. Motor starters.
K. Push-button stations.
L. Power transfer equipment.
M. Contactors.
N. Remote-controlled switches, dimmer modules, and control devices.
O. Battery inverter units.
P. Battery racks.
Q. Power-generating units.
R. Voice and data cable terminal equipment.
S. Intercommunication and call system master and staff stations.
T. Television/audio components, racks, and controls.
U. Fire-alarm control panel and annunciators.

V. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
W. Monitoring and control equipment.
X. Uninterruptible power supply equipment.
Y. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.
Z. Receptacles

3.2 INSTALLATION

A. Verify identity of each item with Corning Facilities Group before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Colors for 208/120-V Circuits:

A. Phase A: Black.
B. Phase B: Red.
C. Phase C: Blue.
D. Neutral: White.

2. Colors for 480/277-V Circuits:

A. Phase A: Brown.
B. Phase B: Orange.
C. Phase C: Yellow.
D. Neutral: Grey

3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

H. Underground Line Warning Tape: During backfilling of trenches install a continuous underground line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

I. Identification of panels that contain a “HIGH LEG”. On a 4-wire delta connected panel that has the midpoint of one phase grounded, shall be marked with an orange label with black letters as follows:

CAUTION ”B” PHASE OF THIS PANEL CONTAINS A “HIGH-LEG”

J. IWMS Numbers:

1. All electrical devices shall be assigned a IWMS number by the IWMS administrator according to the chart below. Numbers shall begin with the device code followed by the building designation. The building designation will be followed by the sequential numbers assigned by the IWMS administrator. (i.e. SW-PR-526).

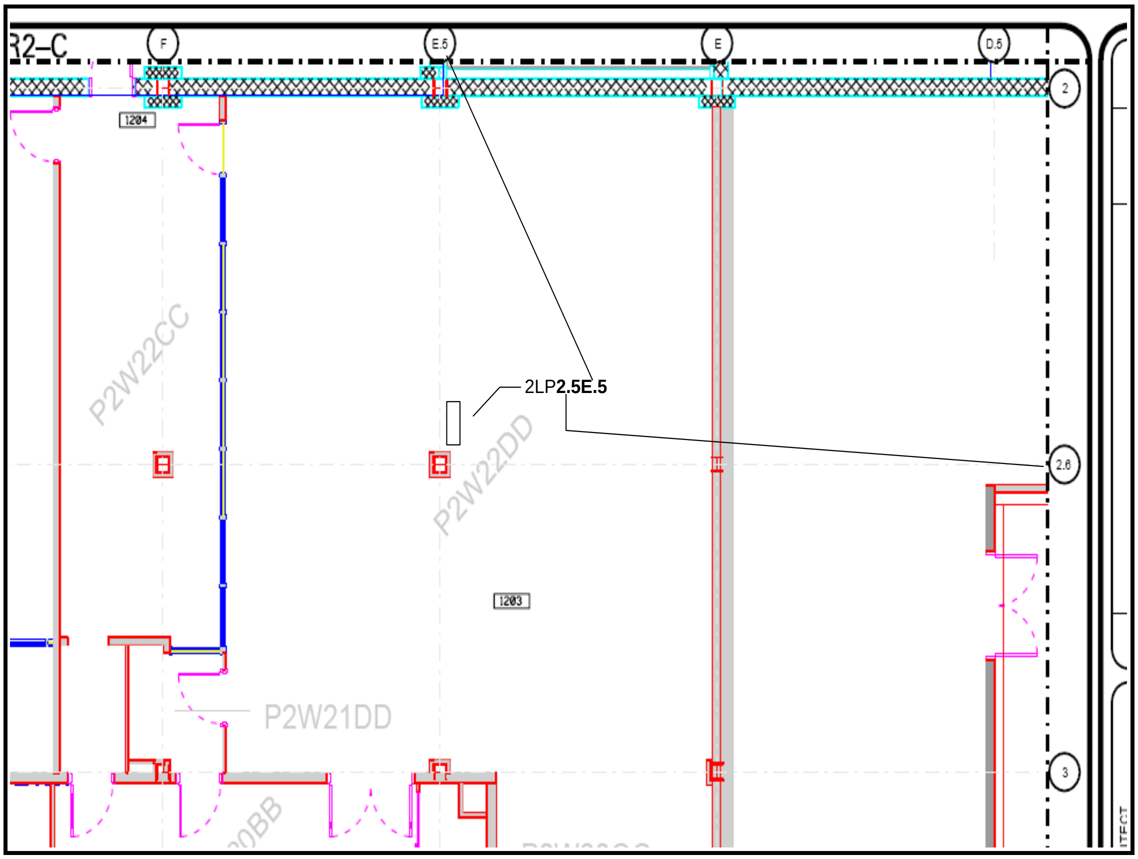
K. Labeling Examples: Refer to the following pages for labeling examples.

ALL ELECTRICAL DEVICES SHALL BE ASSIGNED AN IWMS NUMBER BY THE IWMS ADMINISTRATOR ACCORDING TO THE CHART BELOW. NUMBERS SHALL BEGIN WITH THE DEVICE CODE FOLLOWED BY THE BUILDING DESIGNATION. THE BUILDING DESIGNATION WILL BE FOLLOWED BY THE SEQUENTIAL NUMBERS ASSIGNED BY THE IWMS ADMINISTRATOR. (i.e. SW-PR-526)			
DEVICE CODE		BUILDING DESIGNATION	
CODE	DESCRIPTION	CODE	DESCRIPTION
SW	Bus Duct Switch	AR	Applied Research Building
SW	Local Disconnect	ARM	Applied Research Mods
CTL	Controller	CFT	Center for Phontic Testing
SUB	Substation	BF	Corning Innovation Support Center
BKR	Breaker	CPT	Center for Fiber Testing
XFMR	Transformer	DVE	Development Building East
UPS	Uninterruptable Power Source	DVW	Development Building West

TS	Transfer Switch	DY	Diesel Building (Stardust)
DEVICE CODE		BUILDING DESIGNATION	
CODE	DESCRIPTION	CODE	DESCRIPTION
SWB	Switch Board	DX	Development Expansion Building
JB	Junction Box	FE	Fiber Development Building
RS	Receiving Station	FR	Fundamental Research Building
BD	Bus Duct	HC	H-Class Building
GEN	Generator	NC	North Chiller Building
MCC	Motor Control Center	PF	SP Parking Garage
PP	Power Panel	PG	PRC Generator Building
LP	Low Power	PR	Process Research Center
VSD	Variable Speed Drive	RS	Receiving Station
LSW	Loop Switch	SC	South Chiller Building
PL	Power and Lighting	ST	Site
SVP	Special Voltage Panel	TD	Technology Development Building
LS	Life Safety	TG	Truck Garage
VLT	Vault	TI	Technical Information Building
LA	Lightning Arrestor	WH	Well House
GOAB	Group Op Air-Break Switch	WW	Data Center
SPD	Surge Protection Device	WT	Water Transfer Station
MH	Manhole	YE	Ceramics Corridor (CCIC)
HH	Handhole	ZV	Corning Services Support Center
NOTE: MCCs, PANELS, SWITCHBOARDS AND BUS DUCTS SHALL BE LABELED ACCORDING TO THE STANDARDS AS INDICATED IN THE ABOVE SECTIONS OF THIS DOCUMENT. ALL EQUIPMENT AND DISTRIBUTION SYSTEMS RESIDING “OUTSIDE” A BUILDING COLUMN AND NUMBER SHALL BE IDENTIFIED AS “ST” FOR A BUILDING CODE. (I.E SW-ST-532)			

3.3 Panel Column Number and Letter:

Panel Location: Each panel shall be identified by its location in the facility. Identifiers are the column number followed by the column grid as illustrated below. Each panel shall also contain a panel schedule (directory).

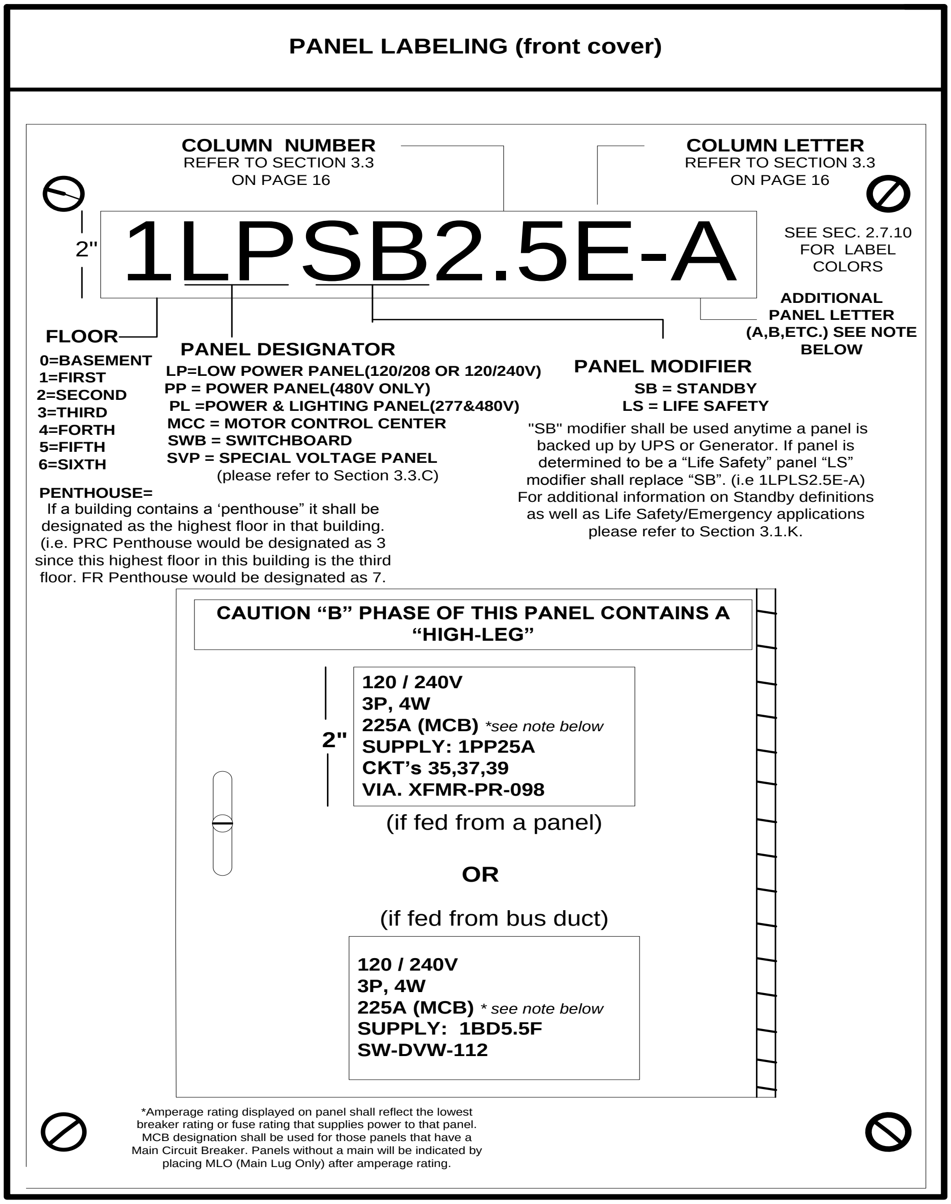


NOTE:

ALL panels are numbered in IWMS with their building location identified (i.e. PR-2LP2.5E). However, the building location is not used when labeling the panel in the field. (i.e. 2LP2.5E) **All distribution systems that cannot be identified by a steel column number and letter(grid) will maintain their floor and panel designations followed by “SITE” and the sequential number as assigned in IWMS . (i.e a power panel residing outside on “South Tank Farm” pad will be labeled 1PPSITE4 in the field and entered into IWMS– (ST-1PPSITE4) Refer to Sullivan Park Building Codes.doc in Onfile for proper building designations.**

1. Panel Labeling:

A. Labeling On Panel:



NOTE:

ALL Panels are numbered in IWMS with their building location identified (i.e. PR-1LP2.5E-A). However, the building location is not used when labeling the panel in the field. (i.e. 1LP2.5E-A) Refer to Sullivan Park Building Codes.doc for all building identifiers.
ADDITIONAL PANEL LETTERS are required when two (2) or more distribution systems are considered one continuous electrical system. (i.e First panel labeled 1LP2.5-A and second panel labeled 1LP2.5-B) Panel A may contain ckt #s 1 through 42 and panel "B" which is not a load of panel A, but rather a continuation of "A" would contain ckt #s 43 through 84.

B. Panel Types:

There are two (2) types of panels throughout the site. They are Process Panels and Facility Panels. All panels throughout the site are assumed to be and considered to be, Facility Panels and are identified as such according to section (3.3.A) above. Process Panels are not identified with a facilities IWMS number and are defined as a panel having one (1) or more of the following characteristics.

Process Panels:

1. Do not remain when\if the process is vacated.

2. Panels that move with the process.

3. Contain a means of disconnect (i.e. breakers) that are integrated into process equipment, control cabinet, or some other means, that are internal to the process and\or equipment.

4. Mobile panels, electrical cabinets, or any type of controllers that are intended to serve as the sole disconnect means for a specific process.

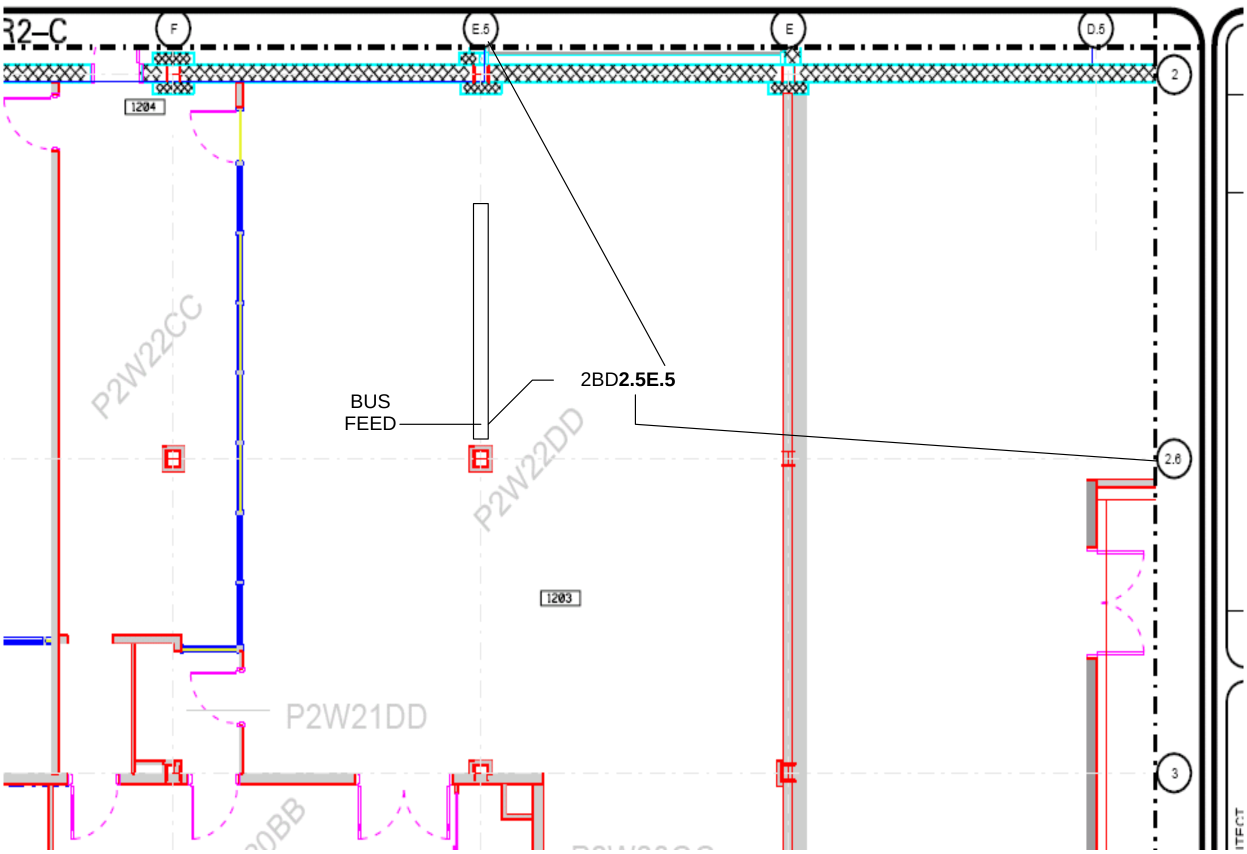
> **NOTE:**
> The intent of identifying Facility and Process Panels is NOT to prohibit or deter individuals from running electrical circuits from them, nor does it imply that these panels are “owned” by a specific process. All Facilities Panels are governed, approved, and documented through the Facilities Engineering Department and the Operations System Change Control Process.

C. SVP Panels:
1. Special Voltage Panels (SVP), are panels that are not 480/277v, 480v, 120/240v, or 120/208v 60Hz standard AC configuration. Special Voltage Panels may include, but are not limited to, direct current panels (DC panels), panels with different modulating frequencies (ex. 50 Hz) or panels with no standard voltages (ex. 400v). In order for a panel to be deemed Special Voltage Panel (SVP), it must be characterized as being a Facilities Panel. Refer to section 1.4.B above for the definition of a facilities panel.

> **NOTE:**
> The intent of identifying Facility Panels as Special Voltage Panels (SVP) is NOT to prohibit or deter individuals from running electrical circuits from them, nor does it imply that these panels cannot be used by a specific process. It is merely to identify panels as having unique characteristics that differentiate them from standard Facility Panels. All Facilities Panels are governed, approved, and documented through the Facilities Engineering Department and the Operations System Change Control Process.

3.4 Bus Duct Column Number and Letter:

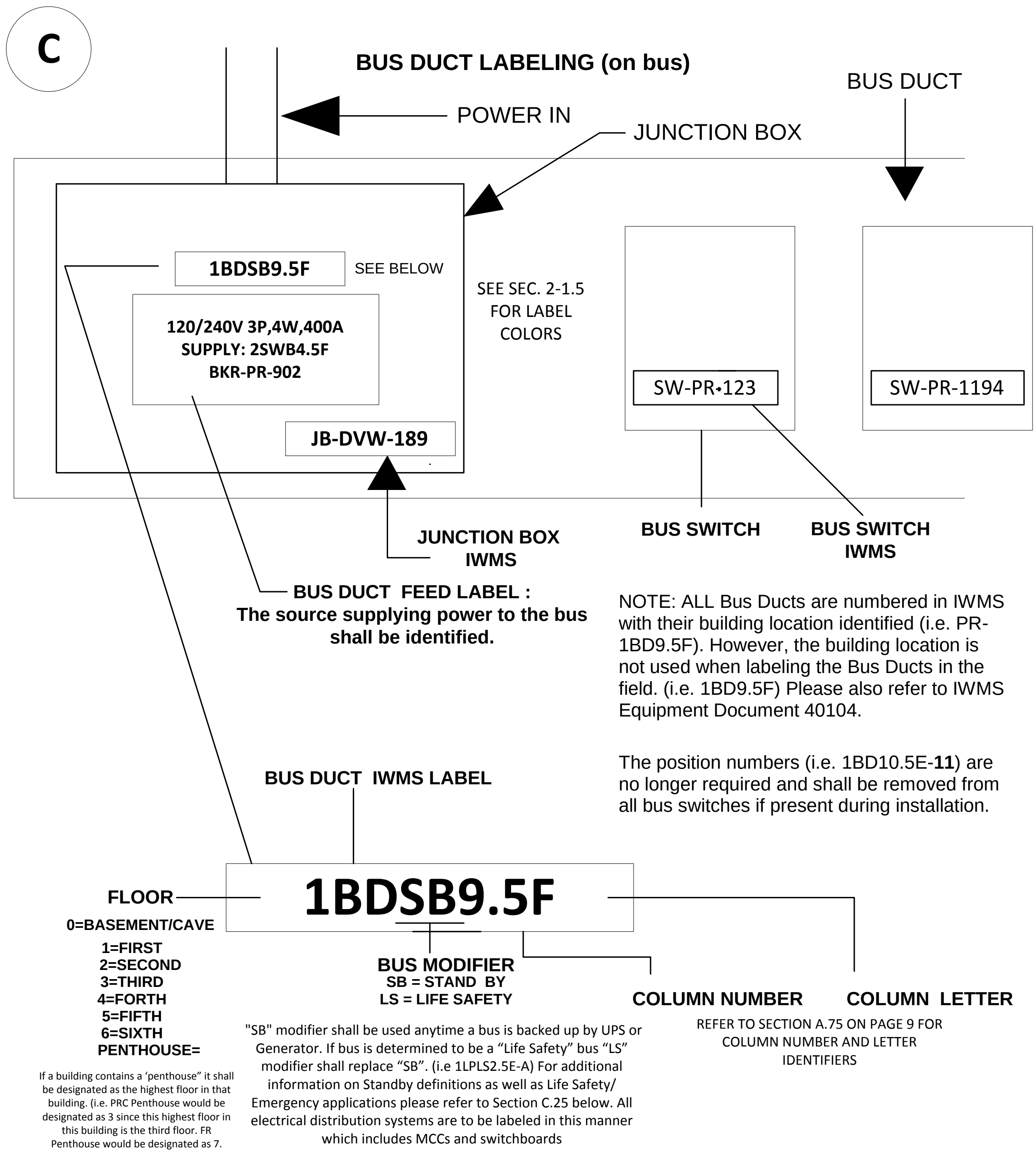
Bus Location: Each bus duct shall be identified by its location in the facility. Identifiers are the column number followed by the column grid as illustrated below. The identifiers shall coincide with where the bus duct feed enters the bus as indicated below



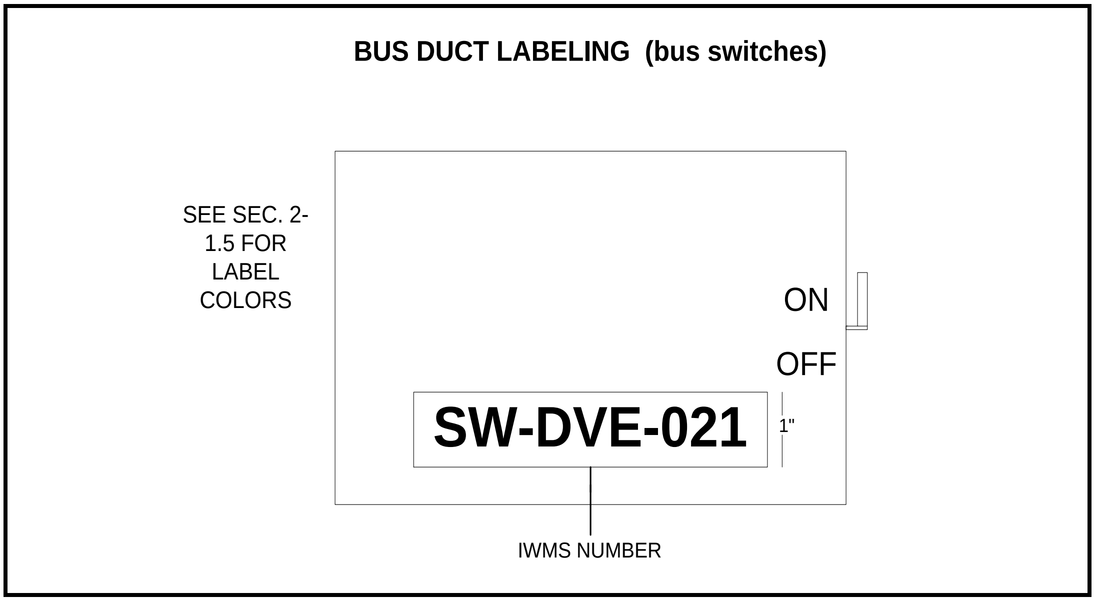
NOTE

ALL Bus Ducts are numbered in IWMS with their building location identified (i.e. PR-2BD17E). However, the building location is not used when labeling the Bus Duct in the field. (i.e. 2BD2.5E) Please also refer to IWMS Equipment Document.

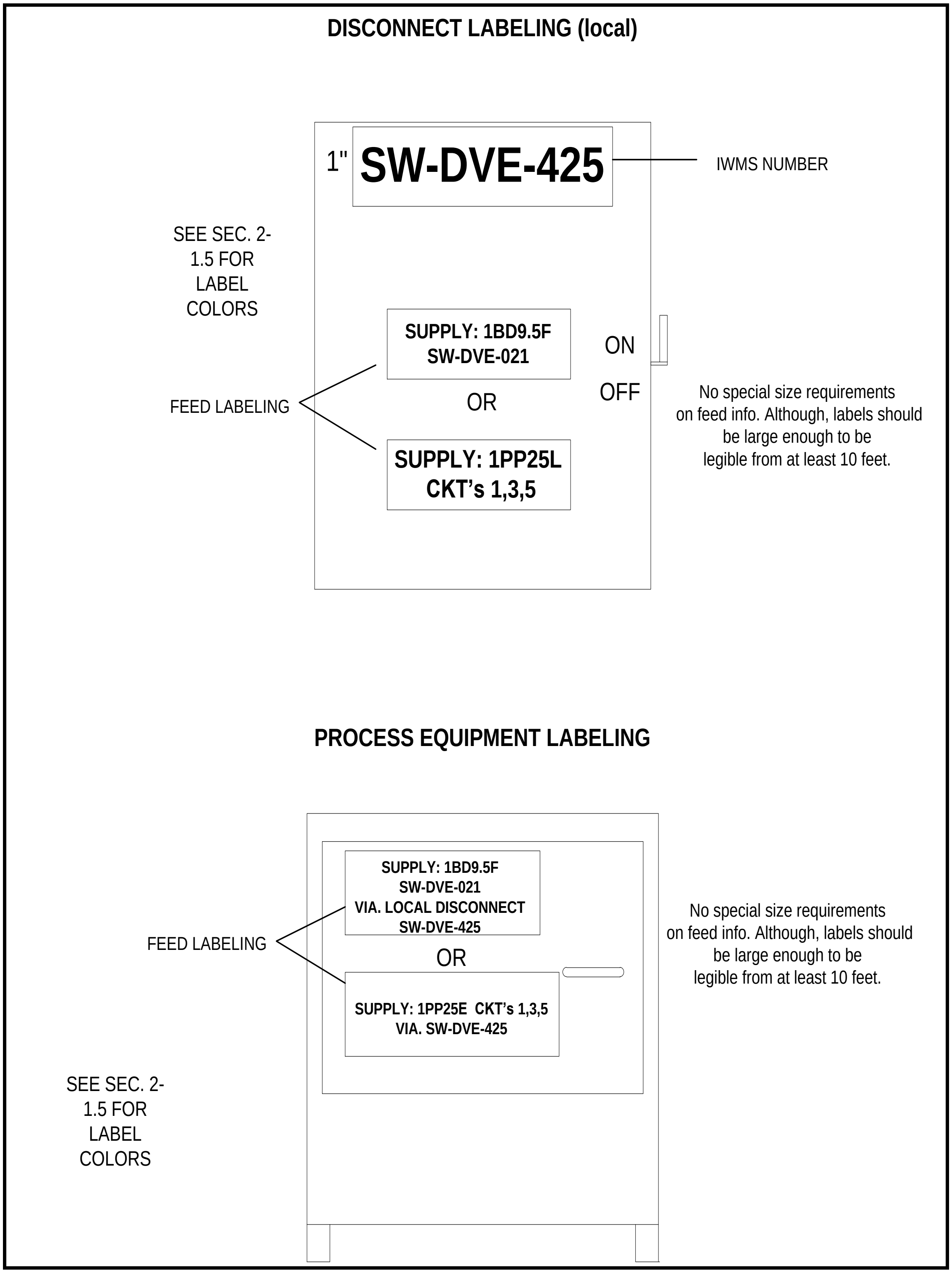
A. Bus Duct Labeling (on Buss):



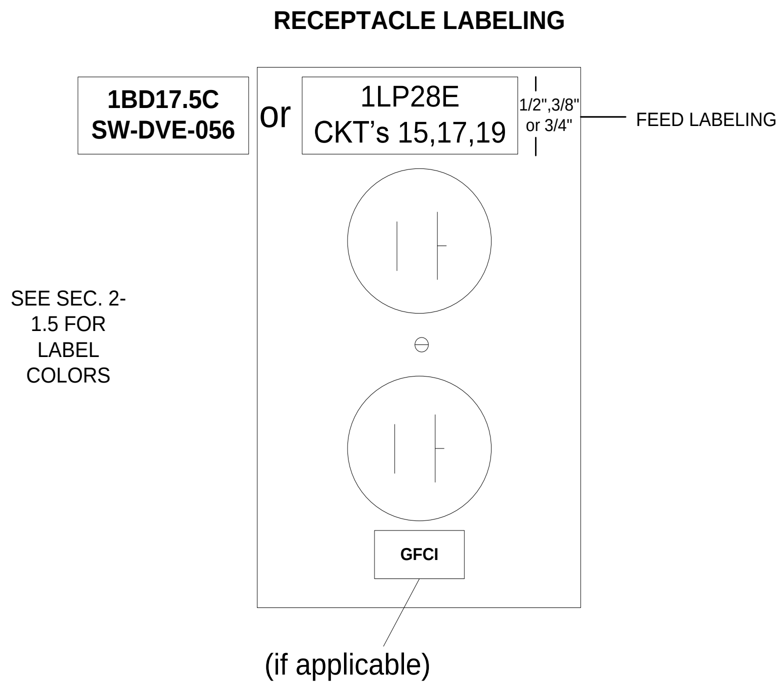
2. Bus Duct Switch Labeling:



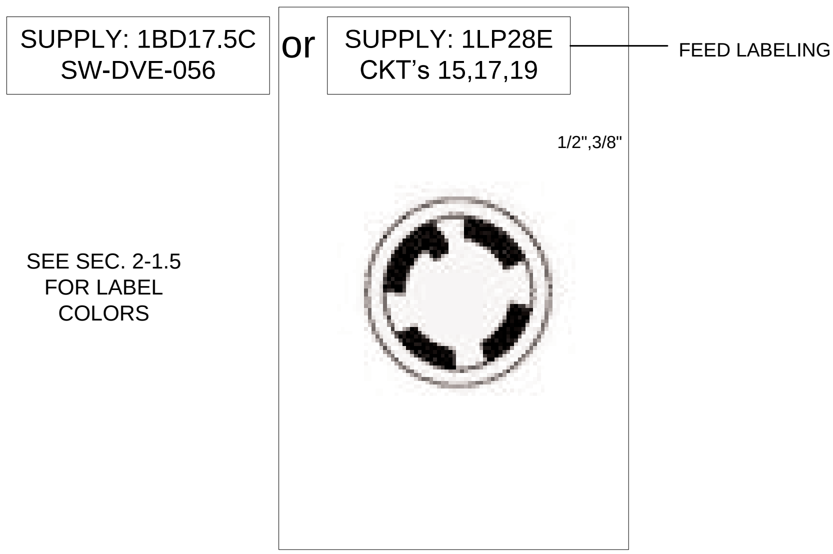
3. Disconnect Switch – Process Equipment – Labeling:



4. Receptacle Labeling:

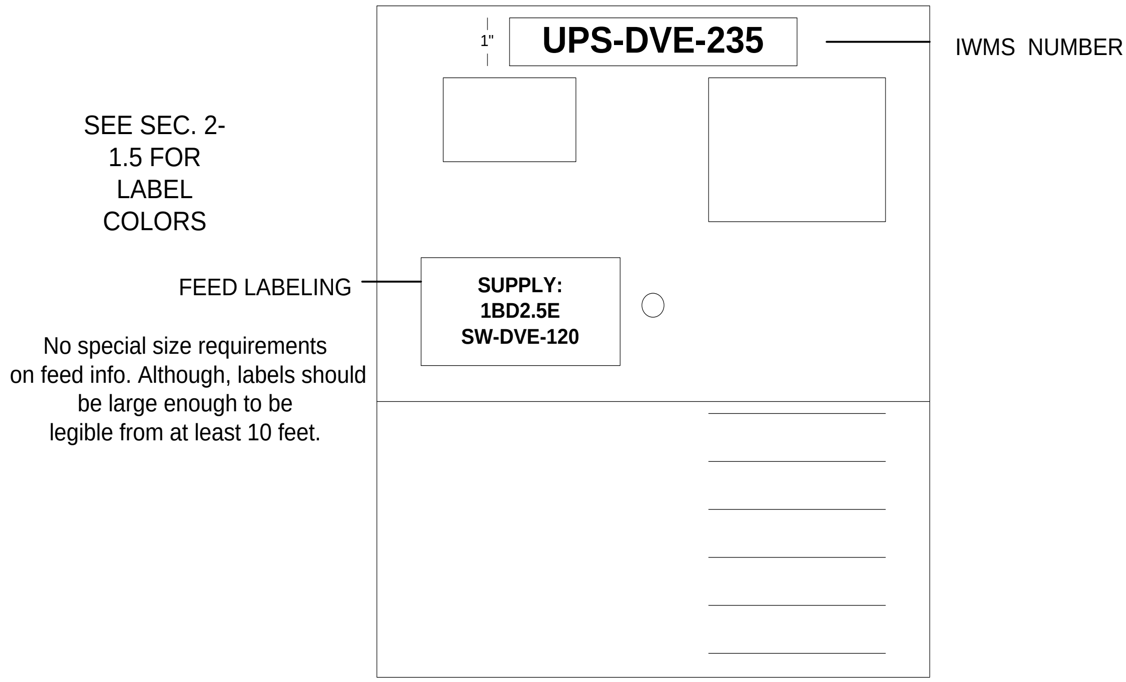


Note: GFCI labeling is required on all receptacles that are protected by such devices. In the event that "normal" receptacles are series fed from GFCI receptacles, each receptacle in series with the actual GFCI receptacle shall also be labeled as GFCI.

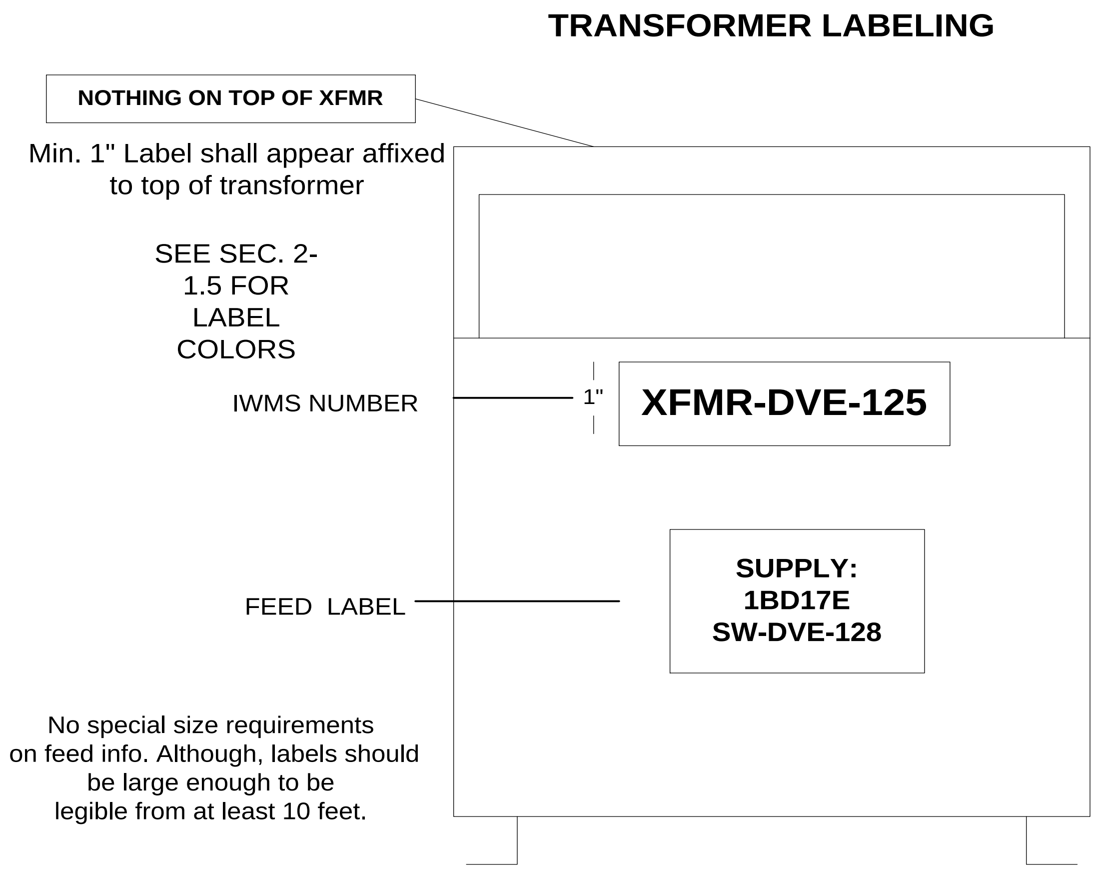


5. Uninterruptable Power Supply Labeling:

UN-INTERRUPTIBLE POWER SOURCE LABELING (UPS)

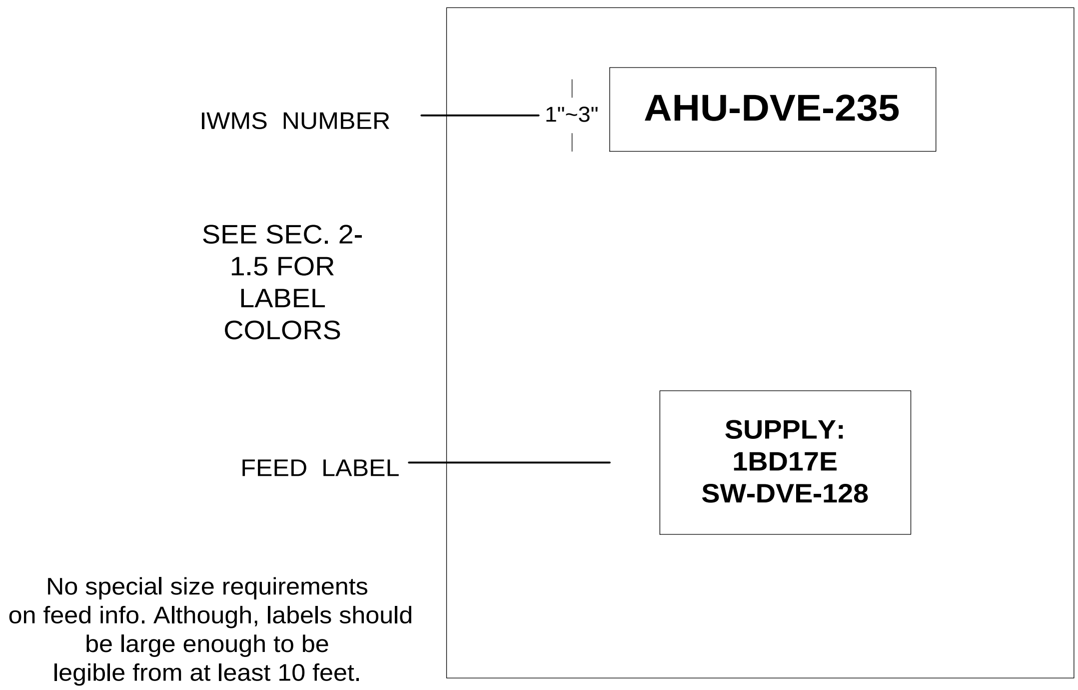


6. Transformer Labeling:



7. Miscellaneous Equipment (Air handling units, exhaust fan, pump, etc.) Labeling

MISCELLANEOUS EQUIPMENT LABELING
(I.E. AIR HANDLING UNIT)



B. Equipment Directory Labeling Examples: Refer to the following pages for directory examples:

1. Substation Directory:

PANEL LABELING (inside panel door)

ELECTRICAL PANEL SCHEDULE - SUBSTATON ← PANEL TYPE (IF APPLICABLE)

BUILDING ABBREVIATION → (XXX BUILDING)

NAME:	(PANEL LABEL/NAME)	STYLE:	(MANUFACTURER AND TYPE)
LOCATION:	(BRIEF DESCRIPTION, CISP RM#)	SERVICE:	(VOLTAGES, #PHASES, # WIRES)
FRAME:	(PANEL BUSS RATING, AMPS)	MOUNTING:	(SURFACE OR FLUSH)
MAIN:	(MAIN BREAKER RATING, # OF POLES)	FEED:	(PANEL OR BUS NAME, BKRS/SW#s, XFMR INFO)

SECTION: 1

	BREAKER IWMS NUMBER (BREAKER FUSED AMPS) SUBSTATION LOW VOLTAGE MAIN	

SECTION: 1

BLANK	**BKR-PR-457** (1600A) SUPPLY TO: SPARE	**BKR-PR-456** (1600A) SUPPLY TO: 1BD7E (P1E57J)	**BREAKER IWMS NUMBER** (BREAKER FUSED AMPS) SUPPLY TO: ATTACHED LOAD (LOCATION OF LOAD)

SECTION: 2

SECTION: 3

IF SPECIFIC PANEL HAS MORE OR LESS SPACES THAN REQUIRED
DELETE\ADD EXTRA PANEL SCHEDULE ROWS AS NEEDED

NAME:	(PANEL LABEL/NAME)	STYLE:	(MANUFACTURER AND TYPE)
LOCATION:	(BRIEF DESCRIPTION, CISP RM#)	SERVICE:	(VOLTAGES, #PHASES, # WIRES)
FRAME:	(PANEL BUSS RATING, AMPS)	MOUNTING:	(SURFACE OR FLUSH)
MAIN:	(MAIN BREAKER RATING, # OF POLES)	FEED:	(PANEL OR BUS NAME, BKRS/SW#s, XFMR INFO)
ADDITIONAL INFO:			

DWG NO.	REFERENCE DRAWNG NUMBER: (REQUIRED)		
	6/19/2013	SCHEDULE DESIGNATOR FROM CONTENTS PAGE (FLOOR/PAGE) →	D

2. Switchboard Directory:

PANEL LABELING (inside panel door)

BUILDING ABBREVIATION → ELECTRICAL PANEL SCHEDULE - SWITCHBOARD (XXX BUILDING) ← PANELTYPE (IF APPLICABLE)

NAME:	(PANEL LABEL/NAME)			STYLE:	(MANUFACTURER AND TYPE)	
LOCATION:	(BRIEF DESCRIPTION, CISP RM#)			SERVICE:	(VOLTAGES, #PHASES, # WIRES)	
FRAME:	(PANEL BUSS RATING, AMPS)			MOUNTING:	(SURFACE OR FLUSH)	
MAIN:	(MAIN BREAKER RATING, # OF POLES)			FEED:	(PANEL OR BUS NAME, BKRS/SW#s, XFMR INFO)	
BKR RATING	BREAKER TRIP RATING	PHASE	PHASE	BKR RATING	125A	
LOAD WATTS	PROVIDE IF KNOWN			LOAD WATTS		
CKT's SLOTS TAKEN UP BY THE BREAKER	EQUIPMENT NAME AND (LOCATION)	A	A	PANEL 1PP23C VIA. XFMR-PR-153 (P1E15Z)		CKT's 2,4,6
		B	B			
		C	C			
BKR RATING	50A	PHASE	PHASE	BKR RATING		
LOAD WATTS				LOAD WATTS		
CKT's 7,9,11,13,15,17	BLANK	A	A	BLANK		
		B	B			
		C	C			
			PHASE	BKR RATING		
				LOAD WATTS		
		A	A	BLANK		
		B	B			
		C	C			
BKR RATING	125A	PHASE	PHASE	BKR RATING		
LOAD WATTS				LOAD WATTS		
	BLANK		A	BLANK		
			B			
			C			
	IF SPECIFIC PANEL HAS MORE OR LESS SPACES THAN REQUIRED DELETE\ADD EXTRA PANEL SCHEDULE ROWS AS NEEDED					
ADDITIONAL INFO:						
DWG NO.	REFERENCE DRAWNG NUMBER: (REQUIRED)					
	6/19/2013	SCHEDULE DESIGNATOR FROM CONTENTS PAGE (FLOOR/PAGE) →				C

3. Panel Directory:

PANEL LABELING (inside panel door)

ELECTRICAL PANEL SCHEDULE

BUILDING ABBREVIATION → (XXX BUILDING)

NAME:	(PANEL LABEL/NAME)	STYLE:	(MANUFACTURER AND TYPE)
LOCATION:	(BRIEF DESCRIPTION, CISP RM#)	SERVICE:	(VOLTAGES, #PHASES, # WIRES)
FRAME:	(PANEL BUSS RATING, AMPS)	MOUNTING:	(SURFACE OR FLUSH)
MAIN:	(MAIN BREAKER RATING, # OF POLES)	FEED:	(PANEL OR BUS NAME, BKRS/SW#s, XFMR INFO)

CKT.NO	DESIGNATION	LOAD WATTS	BKR. TRIP RATING	PHASE	PHASE	BKR. TRIP RATING	LOAD WATTS	DESIGNATION	CKT. NO
1	EQUIPMENT NAME AND (LOCATION)	Provide if known	20	A	A			RECPT's. WEST WALL (P1E54JJ)	2
3	EQUIPMENT NAME AND (LOCATION)	2.2kW	20	B	B			RECPT.'s WEST WALL (P1E54JJ)	4
5	EQUIPMENT NAME AND (LOCATION)	2.2kW	20	C	C			RECPT.'s WEST WALL (P1E54JJ)	6
7	EQUIPMENT NAME AND (LOCATION)	2.2kW	20	A	A			RECPT.'s WEST WALL (P1E54JJ)	8
9	BLUE M OVEN VIA. SW-PR-561 (P1E56L)		20	B	B			LASER VIA. SW-PR-523 (P1E52LL)	10
11				C	C				12
13	BLANK			A	A				14
15	BLANK			B	B			1LP25E VIA.. XFMR-PR-549 (P1E19Z)	16
17	BLANK			C	C				18
19	BLANK			A	A				20
21	BLANK			B	B			RECPT. ON COLUMN C-9 PRC EAST HIGHBAY (P1E24M)	22
23	BLANK			C	C			BLANK	24
25	BLANK			A	A			BLANK	26
27	BLANK			B	B			BLANK	28
29	IF SPECIFIC PANEL HAS MORE OR LESS SPACES THAN REQUIRED DELETE\ADD EXTRA PANEL SCHEDULE ROWS AS NEEDED								30
31									32
33									34
35									36
37									38
39									40
41									42

ADDITIONAL INFO:

DWG NO.	REFERENCE DRAWNG NUMER: (REQUIRED		
	6/19/2013	SCHEDULE DESIGNATOR FROM CONTENTS PAGE (FLOOR/PAGE) →	B

4. Motor Control Center Directory:

PANEL LABELING (inside panel door)

ELECTRICAL PANEL SCHEDULE - MCC ← PANEL TYPE (IF APPLICABLE)

BUILDING ABBREVIATION → (XXX BUILDING)

NAME:	(PANEL LABEL/NAME)	STYLE:	(MANUFACTURER AND TYPE)
LOCATION:	(BRIEF DESCRIPTION, CISP RM#)	SERVICE:	(VOLTAGES, #PHASES, # WIRES)
FRAME:	(PANEL BUSS RATING, AMPS)	MOUNTING:	(SURFACE OR FLUSH)
MAIN:	(MAIN BREAKER RATING, # OF POLES)	FEED:	(PANEL OR BUS NAME, BKRS/SW#s, XFMR INFO)

SECTION: 1	**LOAD WATTS**	PROVIDE IF KNOWN	**SECTION RATING**	**SECTION BUSS RATING**
SW-PR-130 (50A) SUPPLY TO: SPARE	**SW-PR-129** (150A) SUPPLY TO: CENTRAL VACUUM PUMP VIA. SW-PR-624 (P1E25FF)		**SWITCH TABWARE NUMBER** (BREAKER FUSED AMPS) SUPPLY TO: ATTACHED LOAD (LOCATION OF LOAD)	
SECTION: 2	**LOAD WATTS**		**SECTION RATING**	**3000A**
BLANK	BLANK		BLANK	BLANK
SECTION: 3	**LOAD WATTS**		**SECTION RATING**	
SECTION: 4	**LOAD WATTS**		**SECTION RATING**	
SECTION: 6	**LOAD WATTS**		**SECTION RATING**	

IF SPECIFIC PANEL HAS MORE OR LESS SPACES THAN REQUIRED
DELETE\ADD EXTRA PANEL SCHEDULE ROWS AS NEEDED

ADDITIONAL INFO:			
DWG NO.	REFERENCE DRAWNG NUMBER: (REQUIRED)		
	6/19/2013	SCHEDULE DESIGNATOR FROM CONTENTS PAGE (FLOOR/PAGE) →	D

END OF SECTION 260553

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards
For Use At S&T/WPS Facilities.

Document Title	**Electrical Inspection and Testing**
Document Number	**26 08 00.01**
Document Type	**Construction Design Standard**
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Rev #	Revision Originator	Revision Date	Sections Revised	Summary of Revisions made	
1			2.6D,E,F	Revise testing voltage requirements	
2	Laura Masters	6/4/12	All	Removing excess white space, spell check	
2	Laura Masters	6/4/12	1.4	Changing lettering from c., e., f. to c., d., e.	
2	Laura Masters	6/4/12	2.1	Changing numbering from 5., 10., 11. To 5., 6., 7.	
2	Laura Masters	6/4/12	2.13	Changing lettering from A., C. to A., B.	
2	Laura Masters	6/4/12	Apx 5	Adding periods after numbers following standardization w/other Appendix's.	
2	Laura Masters	6/4/12	Apx 6	Moving ":" next to 'Distribution'	
2	Laura Masters	6/4/12	Apx 8	Changing 'torquing' to 'torqueing'	
2	Laura Masters	6/4/12	Apx 12	Moving periods next to 10-21	
2	Laura Masters	6/4/12	Apx 18	Removing extra ':' above 'Meter Tag#'	
2	Laura Masters	6/4/12	Apx 21	Bolding italic note to be standard w/all other notes & moving periods next to 10-25	
2	Laura Masters	6/4/12	Apx 22	Moving periods next to 10-13 & aligning note	
2	Laura Masters	6/4/12	Apx 23	Moving periods next to 10-14	
2	Laura Masters	6/4/12	Apx 27	Bolding italic note to be standard w/all other notes & aligning the note	
2	Laura Masters	6/4/12	Apx 28	Adding the word 'Note', bolding Note section, aligning note, for 13. Changed megets to meets, 18. Changed perpercent to percent, 19. Changed thethen to then, 20. Change pespressure to pressure & actmanual to actual manual, & reformatted data/tables so words would not be split up.	
2	Laura Masters	6/4/12	Apx 30	Adding the word "Note', bolding Note section & aligning note	
2	Laura Masters	6/4/12	Apx 31	Adding the word "Note', bolding Note section, aligning note, aligning Start-Up Checks & aligning 8.	
2	Laura Masters	6/4/12	Apx 32	Adding the word "Note', bolding Note section, aligning note & removing extra period from 12.	

2	Laura Masters	6/4/12	Apx 33	Removing excess white space & right side border of first paragraph	
3	D. Luchaco	07/19	--	Standards Review	

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PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide labor, materials, temporary wiring, testing equipment, technical supervision and services; perform operations required for electrical and mechanical testing of new electrical equipment and circuits being installed; and operations required for electrical testing of each existing circuit being reconnected.

B. Preliminary inspections and testing.

C. Electrical acceptance testing.

D. Related Sections

E. Other Division 26 08 00 Sections where equipment, controls and motors are specified.

1.2 REFERENCES

A. The publications listed below form part of this specification. Each publication shall be the latest revision and addendum in effect on the date this specification is issued for construction unless noted otherwise. Except as modified by the requirements specified herein or the details of the drawings, work included in this specification shall conform to the applicable provisions of these publications.

1. ANSI (American National Standards Institute)

2. ANSI / IEEE 95

3. ANSI / IEEE 400

4. ANSI / IEEE C57.12.11

5. IEEE (Institute of Electrical and Electronics Engineers)

6. IEEE 48 – Standard Test procedure and Requirements for AC Terminations 2.5kV through 765kV.

7. IEEE 81 - Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth

8. IEEE 141 – Recommended Practice for Electrical Power Distribution for Industrial Plants.

   a. NETA (National Electrical Testing Association)

   b. NETA 1.001 Standards for Acceptance Testing of Electrical Distribution Apparatus

1.3 SYSTEM DESCRIPTION

A. Electrical acceptance tests shall be conducted to ensure that electrical materials and their installations are in accordance with the contract documents, regulatory agencies, applicable codes and standards listed herein, and that they may be safely energized.

1.4 QUALITY CONTROL SUBMITTALS:

A. Submit copies of test reports in accordance with requirements of individual Sections and with the following:

1. Submit copies of test reports to the owner including actual readings and corrected readings after each test period.

2. Submit bound copies of final approved test reports at completion of tests to the owner. Maintain copies of the test reports at the site.

3. Test reports shall be signed by persons performing tests and witnesses to tests including, but not be limited to, the following data:

a. Date of test

b. Description of equipment tested

c. Description of test

e. Environmental conditions (Temperature, humidity and weather)

f. Test results (Actual values measured)

e. Comments: Conclusions and recommendations

4. Quality Assurance Summary

a. Preliminary testing and visual inspections shall be conducted prior to operational tests and acceptance to avoid delays.

b. Provide qualified testing personnel the materials and calibrated test equipment to perform inspection and testing.

c. Testing and equipment used for testing shall conform to latest edition of reference specifications specified herein and to the applicable codes and requirements of the local authorities having jurisdiction (AHJ).

d. Review operating instruction and maintenance manuals prior to field testing the equipment.

1.5 CONTRACTOR / TESTING

A. Firms shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems in the voltage levels specified on this project.

B. The lead, on-site, technician shall have current certification by NETA, NICET or other nationally recognized certifying authorities in electrical power distribution system testing.

C. Testing Firm/Contractor shall submit qualifications when requested.

1.6 SCHEDULING

A. Schedule tests with approval of the owner.

PART 2 - EXECUTION

2.1 GENERAL

A. This specification provides guidelines for the inspection, testing, and checkout of the electrical system to ensure that the electrical installation is in accordance with the design specifications, drawings, and Manufacturer's instructions.

B. The listings and descriptions of the inspections, tests, and checks described herein shall not be considered as complete and all inclusive. Additional standard construction checks and tests may be necessary throughout the job.

C. Inspection and test work shall be coordinated with owner's representative. Reasonable notice shall be given to owner to allow witnessing for those tests designated to be witnessed.

D. Where indicated, the tests shall be performed by an independent testing agency with the following qualifications:

1. Testing firm shall be an independent testing organization which functions as an unbiased testing authority, professionally independent of the manufacturer, contractor, and installers of equipment or system evaluated by the testing firm.

2. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.

3. Testing laboratory shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories, Title 29, part 1907.

E. Lead, on site technical person shall be currently certified by the National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.

1. Testing firm shall use technicians who are regularly employed by firm for testing services.

2. Testing firm shall submit qualifications with bid documents when requested.

3. Equipment or circuitry shall not be energized, de-energized, or tied-in to a system without prior review and approval of the test plan and procedure by the site electrical superintendent and the owner's representative.

4. The checks and tests shall be documented on the Quality Control Forms, (See Appendix) or similar forms approved for the project.

5. Construction Quality Manager / Supervisor shall be responsible for all inspection and test activities. A detailed implementation plan must be submitted, reviewed, and approved by the engineer of record.

6. Inspector and test technicians shall be qualified for the work by virtue of training and experience.

7. Examine areas and conditions where testing will be done. Do not proceed with the Work until satisfactory conditions have been achieved.

2.2 APPLICATION

A. Equipment that can be paralleled under any conditions, including defeat of the interlock, shall be tested for proper phasing using hot-phase / hot-stick or other approved methods.

B. Measure full load currents of feeders serving single-phase loads to ensure equal load balance on each phase. Relocate branch circuits as necessary to provide balance.

C. The specified megger values are the minimum acceptance values at ambient temperature of 60 degrees F and low relative humidity. Convert readings to equivalent values at 60 degrees F if measurements are taken under other conditions.

D. Confirm phase rotation at busses, panels, switchboards, switchgear, and motor control centers using a phase sequence meter. Comply with recognized standards (A-B-C left to right, top to bottom, front to back, when facing front of equipment, and to provide A-B-C (1-2-3) clockwise rotation). Where electrical installations are extensions of existing systems or in new buildings at existing sites, phase rotation shall conform to existing conditions.

2.3 EQUIPMENT INSPECTION

A. Confirm the proper installation, support and fastening with equipment manufacturer requirements.

1. Complete assembly of all components and the removal of shipping materials.

2. Tightness of bolted covers, proper gasket fit and missing hardware.

3. Tightness and physical condition of bolted connections, both electrical and structural.

4. Proper support and termination of power and control wiring.

5. Secure ground connections.

6. Verify that instrument transformers, instruments, relays, fuses, circuit breakers, switches and other devices are of proper type, size and rating.

7. Examine equipment sheet metal and components for damage including paint finish and cleanliness.

8. Proper operation of doors, latches, and locks.

9. Verify labeling is affixed per specification 26 05 53 “Identifications for Electrical Systems”.

2.4 PREPERATION

A. Prepare a detailed plan and schedule for inspection and testing activities. Submit to construction superintendent and owner for review. Obtain written permission from owner prior to start of testing.

B. The testing and checkout of electrical equipment such as switchgear, substations, drive equipment, motor load / control centers, and generators may require notification of the proposed checks with the equipment manufacturer's representative. Refer to equipment specifications for requirements.

C. Equipment warranties or guarantees shall not be voided by testing and checkout work. Coordinate all testing with equipment manufacturers prior to any testing.

D. The checks and tests shall be a supplemental to, and compatible with, the manufacturers' installation instructions.

E. Where deviations are identified, the manufacturer's review documentation shall be obtained before testing.

F. Reasonable cooperation shall be extended to permit witnessing by the manufacturer's representative if so requested.

G. Where any questionable repairs, modifications, significant adjustments, tests, or checks are to be made, the test supervisor shall contact the electrical superintendent to determine if the work should be performed by, or with the, manufacturer's representative.

H. Serial and model numbers of the instruments used shall be recorded on the test forms.

I. Testing and checkout work shall be performed by qualified personnel.

J. The test apparatus shall be of the proper voltage class and rating for the test being performed. Care shall be taken that the installation shall not be overstressed.

K. Initial resistance and low voltage tests of equipment shall be made with the equipment de-energized and with all electrical connections to the devices disconnected and locked out as required.

L. Proceed with testing after resistance measurements on devices meet requirements. Any shorts or grounds shall be corrected before the circuit is energized.

M. Full voltage tests on circuits and equipment shall be performed only after owner approval. The owner shall be present and witness full voltage tests. If required by equipment specifications, the manufacturer's representative will witness full voltage tests.

N. Equipment purchased by contractor or pre-purchased by the owner for the contractor to install shall be inspected and tested. Refer to the equipment specifications for additional requirements.

O. Electrical equipment or systems determined to be damaged, faulty, or requiring repairs shall be reported to the owner. Corrective actions will require owner approval prior to any work being completed.

P. Review the construction documents and manufacturer's shop drawings to establish the inspection and testing work required under this section.

Q. Provide the coordination and scheduling of the work of this section with the work of related trades.

R. Testing of outdoor equipment shall not be performed during inclement weather and ground resistance tests on direct buried ground conductors or rods shall not be performed within 48 hours after rainfall.

S. Megger and high potential testing shall not be performed during periods of high relative humidity. Locate personnel where exposed cables, bus work, connections, or other components exist during megger and high potential testing.

T. Clean equipment thoroughly prior to testing. Vacuum interiors of cubicles and remove foreign material. Wipe clean all insulators, bushings, and bus supports using a lint free cloth.

U. Preliminary testing and visual inspections of the electrical installation, including verification of the factory wiring, shall be conducted prior to any operational testing.

V. Where the equipment or system under test is interconnected with other equipment, systems, or controls for proper operation, the other equipment shall be operated simultaneously with equipment or system under test.

W. Provide the adjustment of protective devices in accordance with the approved coordination study.

X. Verify that all Arc Flash Labels have been installed on switchgear, switchboards, panels, MCC's, switches, controllers, etc.

Y. If motors or transformers require drying out to obtain required insulation values, drying method shall be in accordance with manufacturer's recommendations.

Z. Verify that shipping devices and restraints have been removed.

AA. Check for proper interconnection and tightness at all connections of shipping sections.

2.5 SAFETY

A. Safety practices shall conform with, but are not limited to, the following requirements:

1. OSHA
2. National Safety Council Manual Accident Prevention for Industrial Operations
3. Applicable state, local safety codes and operating procedures
4. American National Standards for Personnel Protection
5. National Fire Protection Association, NFPA 70E
6. Owner's safety practices

B. The test supervisor shall ensure that the testing and checkout work is conducted in a safe manner. Special safety precautions shall be utilized, including:

1. Locking and tagging procedures
2. Barricades
3. De-energization or isolation of equipment before testing
4. Review of procedures with safety personnel
5. Erection of warning signs
6. Stationing of guards and watchmen
7. Maintenance of voice communications
8. Personnel orientation
9. Review and understanding of construction drawings.
10. Review and understanding of installation, start up and O & M manuals.
11. Exposed live parts subjected to testing shall be guarded by personnel, barricades, or other practical means to insure against personnel being injured by coming in contact with or in close proximity to exposed live parts.
12. Equipment, exposed live parts, etc. shall be completely discharged by grounding or other accepted methods to eliminate possibility of injury to personnel from electrical shock after tests have been completed.

13. Exposed rotating or moving parts of equipment shall be guarded by personnel, barricades or other practical means to insure against personnel being injured during testing of such equipment.

14. Provide suitable safety equipment, which is readily accessible during testing operations, and follow owner's on-site safety regulations.

15. Tests shall be performed with the apparatus de-energized. Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.

2.6 SPECIFIC EQUIPMENT AND CABLE TESTING

A. Grounding systems

1. Test building ground loops and major equipment grounds to remote earth or directly referenced to an extremely low resistance (approximately 2 ohm) reference ground benchmark. Visually inspect systems, raceway, and equipment grounds to determine the adequacy and integrity of the grounding.

2. Test the ground grids for ground resistance to verify a maximum ground resistance as indicated in Appendix A, Grounding Table.

3. The fall-of-potential method using two (2) supplementary ground electrodes, or other suitable approved method, shall be used to determine ground resistance values. Refer to 26 05 26 Grounding and Bonding.

4. Testing shall be performed as described in IEEE Standard 81, Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth.

5. For additional testing requirements, refer to Section 26 05 26, “Grounding and Bonding”.

B. Low Voltage Motor Control Centers (MCC)

1. Before performing any tests, visually inspect the MCC (externally and internally) for damage. Wipe down the MCC to remove all construction dirt and dust.

2. With all the starters open, including the main feeder breaker, megger the bus phase-to-phase and phase-to-ground using a 500 volt megger. Insulation resistance shall be at least 3 megohms.

3. Confirm that the starter overload heaters or solid state overload relays are sized in accordance with the manufacturer's instructions for the motor nameplate full load current.

4. Before motors are run for plant startup, megger motor cables with a 500 volt megger with the motor connected. Jog motor to determine correct rotation.

5. After rotating is confirmed correct, set the motor circuit protector breakers in accordance with the manufacturer's recommended procedure, or verify proper fuse ratings in fusible disconnect switches.

6. With motor overloads removed, confirm proper operation of the motor control circuit including start and stop permissive, interlocks, and trip functions.

7. For additional testing requirements, refer to Section 26 24 19, “Motor Control Centers.”

C. Low Voltage Motors

1. At the time of motor receipt, visually inspect each motor for any physical damage.

2. Check motors for proper lubrication.

3. Prior to connection of equipment and energization, test motors for short circuits and grounds. Check bearings for lubrication and rotate shaft manually. Use megohm meter to determine insulation levels. Megger as follows:

   a. Test voltage shall be 1,000 Vdc for 460 volt-rated motors and 500 Vdc for 200 volt and below rated motors, applied for 60 seconds.

   b. Acceptable test results shall be 20 megohms for 460V and 200V, 3- phase motors and 5 megohms for 115V, 1-phase motors, maintained for duration of test.

4. Uncouple motor and test (bump) motor by applying voltage to determine correct direction of rotation.

5. Measure full load readings of each motor and verify that correct heater size heater elements are installed in overload relays.

6. Measure speed of motor using tachometer.

7. Provide motor test data for each motor. Tests shall include, as a minimum, direction of rotation, rpm, voltage, amperage, noise level, nameplate data, and equipment type where motor is used.

8. Before energizing any machine, visually inspect for serviceability. Check Manufacturer's instruction manual for correct lubrication and ventilation. Verify that proper alignment has been performed. Check nameplate for electrical power requirements.

9. Test run motors, uncoupled or unloaded, before placing into regular service. Check the motor for rotation, speed, current and temperature rise, and record the results.

D. Transformers (600 VOLT OR LESS)

1. After primary cable connections are complete, perform an insulation test by means of a 1000 volt DC megger on all 480 volt primary, dry type transformers.

2. Megger the feeder cable with the primary winding; the feeder overload protective device shall be open.

3. Secondary leads may be meggered with the secondary windings; the load disconnect device shall be open.

E. Check continuity and correctness of windings connections. Use the following test values:

Transformer Winding	Megger Test Voltage	Minimum Megger Reading Megohms
480 Volt Primary	1000	45
208 / 120 Volt Secondary	1000	30

F. Maintain megger test voltages for 1 minute.

G. For additional testing requirements, refer to Section 26 12 16, “Dry Type Medium Voltage Transformers”.

1. 600 Volt Wire and Cable

H. Before energizing, measure the continuity and insulation resistance of every circuit external to equipment with a megger from each wire to all others, and ground. Normally, conduct tests at 500 volts DC or lower.

I. Take insulation resistance measurements of the following:

1. Feeder Circuits: Measure insulation resistance of feeder circuits with connections to circuit breakers made up, but with breakers open and load not connected.

2. Lighting Panel Feeders: Measure insulation resistance of lighting panel feeders with circuit breakers, lighting transformers, and panelboards connected, but with lighting branch circuit breakers or switches open.

3. Lighting Branch Circuits: Measure insulation resistance after lamp holders, receptacles, fixtures, and other similar items are connected but before lamping.

4. Motor Feeders: With motors disconnected, measure insulation resistance of motor feeders from load side of contactors or circuit breakers. Repeat this test after motors are connected and just before energizing at perhaps lower voltage as limited by the maximum test voltage for the motor.

5. Motor Control Circuits (600 V): With pushbuttons and over current devices connected, measure insulation resistance from phase-to-ground only. It may be necessary to lift the neutral ground on the control transformers to perform this test. Also, isolate any control elements that should not be meggered.

6. Check cables and wires for proper identification numbering or color coding.

7. For additional testing requirements, refer to Section 26 05 19, “Low Voltage Electrical Power Conductors and Cables”.

J. Circuit Breakers

1. Compare nameplate data with drawings and specifications

2. Check removable circuit breaker elements making sure mechanical operation and contact alignments are true. Retighten loose bolts.

3. Place the drawout circuit breaker elements for each unit in its compartment.

4. Rack in and out the breaker element and observe the three breaker element positions: In, Out, and In Between. Check to make sure that the breaker element shall be held rigidly in the "In" (operating) position without locking bolts.

5. Manually operate each circuit breaker and make sure that the mechanism operates freely and without binding.

6. Test the automatic circuit breaker trip. This shall be accomplished manually with power to the switchgear off.

K. Medium Voltage Surge Protection Devices

1. Visually inspect each lightning arrestor for physical damage and conformance with design specifications and Manufacturer's recommended installation procedures.

2. Check each arrestor for conformance with contract specifications and documents. Make sure the arrestor is of the exact voltage rating and class as specified.

3. Check each arrestor for mounting and connection arrangements. Make sure the arrestor has been installed with adequate mounting and clearance requirements.

L. Batteries and Chargers

1. Visually inspect batteries and charger for physical damage and conformance with design specifications and Manufacturer's recommended installation procedures.

2. Take specific gravity and temperature readings.

3. Verify charging equipment operation by measuring charging current and voltage using Manufacturer's recommended procedure.

4. Record temperature, electrolyte level, charging rate, specific gravity, and individual battery cell voltages. Check all alarms.

5. Set charger float and equalizing voltage levels.

M. Medium Voltage Cable

1. Conduct cable tests on new and existing cables in accordance with ICEA-CEMA, NETA, and AEIC specifications, and at the maximum durations and direct current potentials specified herein.

2. Perform cable tests when the cable is received at the project location, and after cables are installed and all splices and terminations are complete, and before connection of any apparatus, equipment, or bus.

3. For additional test requirements, refer to Section 26 05 13 – Medium Voltage Cables. The maximum test criteria stated shall apply.

4. Do not energize cables at system voltage before acceptance testing, but do so as promptly as possible after successful completion of tests.

5. Perform an insulation resistance test for each phase conductor with other conductors and shields solidly grounded. Do not test phase conductors simultaneously.

6. Test duration shall be 10 minutes with resistances tabulated at 30-second, 1-minute, and 10-minute intervals. Calculate dielectric absorption ratio and polarization index.

7. Minimum acceptable insulation resistance shall be 1 megohm per 1000 volts of operating voltage.

8. Perform a DC high potential test on cables in accordance with 26 05 13 “Medium Voltage Cables”. Adhere to precautions and limits as specified in the applicable NEMA standard for the specific cable. Perform tests in accordance with ANSI / IEEE Standard 400.

9. Apply grounds for a time period adequate to drain all insulation stored charge. Proper notification must be made to all concerned parties if grounds are left in place.

10. When new cables are spliced into existing cables, megger test the new cable while on the reel.

11. After test results are approved for new cable, and the splice is completed, perform an insulation resistance test and a shield continuity test on the length of new and existing cable including the splice.

12. After a satisfactory insulation resistance test, perform a DC high potential test on the entire cable, utilizing a test voltage recommended by the testing firm and approved by the contractor's representative.

13. Testing contractor shall be independent of the contractor, manufacturer and installing contractor of the cable system.

2.7 SECONDARY UNIT SUBSTATIONS

A. General

1. Before performing any tests, confirm that the incoming power is off and remains off to the unit substation while being tested. For safety, ground incoming cables to ground using a shorting strap. If power is on to the incoming switch, lock the switch in the open position and do not perform any tests on the switch.

2. Obtain the recommended testing procedure for each component of the substation from the substation manufacturer.

3. Before testing, record all nameplate data from the various components such as disconnect switch, transformer, structure, and breakers. This nameplate data shall also be on each corresponding test sheet.

4. For additional test requirements, refer to Section 26 11 16, “Secondary Unit Substations”.

2.8 MEDIUM-VOLTAGE DISCONNECT SWITCHES AND LOAD INTERRUPTERS

A. Before making any inspection or tests of the switch, ensure incoming power is off and remains off. After doing this, ground incoming cables with a grounding strap.

B. Visually inspect the switch for apparent damage during shipment or construction.

C. Each switch shall be manually operated, moveable, and stationary contacts observed for proper alignment, mating, and seating.

D. The switch mechanism shall operate freely or be adjusted to do so.

E. Observe and check the switch safety interlocks and auxiliary contacts for proper operation.

F. Perform insulation resistance tests with a 2500 volt megger on each pole, phase-to-phase and phase-to-ground for 1 minute.

G. Minimum acceptable resistance shall be 1000 megohms.

H. Perform a DC over potential test at the maximum test voltage listed below on each pole of the switch with the switch closed. Do not conduct over potential tests until the insulation resistance levels are at the proper values.

I. Over potential Test Voltages

Rated kV	Test Voltage	
	AC	DC
5	14.3 kV	20.2 kV
15	27.0 kV	37.5 kV

J. For additional testing requirements, refer to Section 26 11 16, “Secondary Unit Substations”.

2.9 POWER TRANSFORMER

A. The transformer contractor has been contracted to perform factory acceptance testing and on site acceptance testing. The electrical contractor shall be present to assist and support the manufacturer’s representative during the entire on site start-up and testing process.

B. Transformer contractor shall perform all routine test listed in ANSI C57.12.90, plus additional tests as specified in Section 26 12 00 “Medium Voltage Transformers, Section 26 12 13 “Liquid Filled Medium Voltage Transformers”, or Section 26 12 16 “Dry-Type Medium Voltage Transformers”.

C. Upon arrival at site, contractor shall visually inspect the transformer for apparent damage during shipment or construction. Check bolt connections and ensure they are securely torqued. Remove construction dirt and dust from the unit.

D. Carefully check for cracked bushings, leakage of insulating oil, entrance of moisture, or the loss of inert gas (if unit is shipped with Nitrogen).

2.10 LOW VOLTAGE SWITCHGEAR

A. Before making any tests, visually inspect the switchgear lineup externally and internally for damage or possible trouble.

B. With feeder breakers open, including the main secondary breaker, megger the bus phase-to-phase and phase-to-ground using a 500 volt megger. Insulation resistance values shall be at least 3 megohms.

C. Using a primary injection testing device, test the breakers for proper trip operation. Test at the trip settings supplied by the owner. Visually inspect to see if the CT ratio is correct for the breaker rating, and manually operate each breaker to ensure that the breaker is not binding.

D. Rack the breakers into position in their respective cells to check for proper alignment. Adjust breaker solid-state trip devices according to the settings provided by Contractor's Representative.

E. After being completely tested, tag each breaker showing test completion. The tag shall show company's name performing test, tester's name, and date of test.

F. Test the automatic transfer scheme where applicable to confirm operation as described in the sequence of operations.

G. For additional testing requirements, refer to Section 26 11 16, “Secondary Unit Substations.”

2.11 MOTOR CONTROL CIRCUITS (600 V)

A. With pushbuttons and over current devices connected, measure insulation resistance from phase-to-ground only. It may be necessary to lift the neutral ground on the control transformers to perform this test. Also, isolate any control elements that should not be meggered.

B. Check cables and wires for proper identification numbering or color coding in potential transformers.

2.12 INSPECTION AND TEST OF ELECTRICAL INSTALLATION

A. Inspectors shall carefully review installation specifications issued for the project. They shall be familiar with applicable codes / standards and shall have copies available at the work locations for reference. Certain requirements may be defined in the specifications but not called out on drawings, such as expansion joints in conduits, breathers and drains, and support for cable in vertical conduit runs.

B. Additional inspections may be carried out by third parties to meet legal requirements. City, state, or similar inspection shall not alleviate the requirement for inspection defined here.

1. Underground Electrical

    a. Inspect the in progress installation of the ground system. This activity shall include the following:

ii. Ground rods: for correct type and depth.

iii. Ground conductors and connections: as each portion of the system is installed and prior to backfilling.

b. Verify that system is being installed in accordance with drawings. Ascertain that a record set of drawings reflecting as-built marks is being maintained.

e. Color code Underground Drawings as required tracking in-progress installation. Document the inspection of the completed system for each Area.

f. Test the resistance to earth for each ground rod, or designated group of rods, or each foundation, as required by the drawings and specifications. Document the test data on Attachment 19, Grounding Anode Testing Test Record.

g. Inspect in-progress duct bank and electrical manhole installations using Appendix 7 / 8 and Inspection Checklist, as guides. Ensure that a record set of drawings reflecting as-built marks is being maintained.

2. Above Ground Electrical

a. Panelboards

b. Inspect and test bonding to ground for equipment and structures in accordance with Appendix 11.

c. Inspect the in-progress installation of all cable in accordance with Section 26 05 19 “Low Voltage Electrical Power Conductors and Cables”. Medium voltage cable terminations shall be inspected in accordance with Appendix 8.

d. Inspect conduit seals and ensure that all seals have been poured after all cables have been pulled, tested, and Instrument Loop Checks completed refer to Appendix 5. Document the inspection for each area / unit on Appendix 3, Conduit Sealing Inspection Record.

e. Wiring devices and receptacles refer to Section 26 27 26, “Wiring Devices”.

f. Circuit and motor disconnects, refer to Section, 26 28 16 “Enclosed Switches and Circuit Breakers.”

g. Engine Generators and Transfer Switches; refer to Sections 26 32 13 and 26 36 00.

3. Ground Test Methods

a. Test Method A is basically a true resistance test to remote earth. The current reference rod C2 is driven approximately 4 feet deep and 1000 feet from the ground under test. The direction chosen should be such as to facilitate the location of the potential reference rod P2 in line with the C2 rod. A minimum of at least 5 readings shall be taken with the P2 rod driven approximately 2 feet deep in line, preferably at distances of 100, 300, 500, 700, and 900 feet from the ground under test. Plot a curve as the readings are taken of ground resistance in ohms versus distance of the P2 rod in feet. The value of resistance in the flat area of the curve at which the slope reverses direction (positive slope changes to negative slope) is the True Resistance of the ground under test. This method of test is normally used on the more important facility grounds such as main generator and substation system neutral and equipment grounds, and to establish one or more reference ground benchmarks at the site.

b. Test Method B a 2 point short version of Method A and is usually quite satisfactory for isolated electrodes or grounds usually of shallow depth. This type test is usually adequate and convenient for use in testing overhead line and related equipment grounds. The current reference rod C2 is driven 300 feet from the ground under test. The P2 potential rod is driven approximately half way in line with the C2 rod, about 150 feet from the ground under test. A ground resistance reading is taken and then the P2 rod is moved either approximately 20 feet further or closer than the 150 foot point and another reading is taken of the ground under test. If the readings agree or if the latter is within 5 percent of the former, average the readings and accept this as the correct resistance of the ground under test.

c. Test Method C may be termed the Direct Reference method whereby the test instrument is used as a direct reading ohmmeter. One set of leads (P1 and C1) is connected to ground under test and the other set of leads (P2 and C2) is connected to a reference ground benchmark that has previously been tested to remote earth by Method B. It is important that the reference ground used has very low resistance to remote earth, usually less than 2 ohms is preferred. The test result obtained is the sum of the ground under test to earth and that of the reference benchmark to earth as a maximum reading. If the reference benchmark by previous test to remote earth is negligible, then the reading obtained may be taken as that of the ground under test. Otherwise, the readings should be subtracted and the result would be considered as a maximum resistance to remote earth of the ground under test.

2.13 INSULATION TEST METHODS OF EQUIPMENT AND CABLE

A. General

1. The contractor shall perform (or have performed by the independent testing firm) DC insulation tests of the types specified. Testing is required for electrical equipment (motors, generators, transformers, power circuit breakers, switches, switchgear, motor control centers, bus duct, and similar electrical equipment), apparatus, and cables; under any one or more of the conditions described below:

a. Where delivered or turned over to the contractor for care, storage, or installation.

b. Before equipment energization or placing equipment into service, with the acceptance by the owner.

c. When damage to the insulation is suspected or known to exist.

d. After any repairs or modifications to the equipment that affect the installation.

e. Routinely as necessary to determine or evaluate the condition of the insulation, especially related to moisture conditions, to determine the need for drying, cleaning, or other maintenance work or protection.

f. Where lightning or other surge conditions are known to have existed on the circuit.

2. Insulation tests are required by the contractor or the independent testing firm at various stages of construction. The equipment, cable and s systems that require testing, the maximum test voltages, and the type test required are specified under the specific equipment type.

3. Test Methods - four types of insulation tests are referred to or required by this specification. They are briefly described below. At the conclusion DC tests, grounds shall be applied to the cable or equipment windings for at least twice as long as the duration of the applied voltage. This is needed to discharge the capacitive voltage built up during the test.

a. Proof Test requires the application of DC voltage in excess of the equipment rating. The test voltage is held constant for a specified time and the behavior of the insulation current, voltage, and resistance are observed for changes that may indicate approaching failure or poor insulation conditions. The magnitude of the insulation resistance is also considered in the evaluation of the insulation. This test may be conducted with a constant voltage megger or variable voltage source as appropriate.

b. Step Voltage Test applies the voltage to the insulation in consecutive steps of specified magnitude to a maximum value in excess of the equipment rating. The voltage is held constant at each step for a selected period of time, usually 1 minute. At the end of each period, the insulation resistance is determined by the measurement of the current and voltage. A curve of resistance versus voltage is plotted as the data is obtained. At the final test voltage step, the voltage is usually held constant for an additional period of time, usually 3 minutes, and readings taken at 1 minute intervals. The behavior of the meters is closely observed during the entire test. The test is stopped at any voltage step if results show questionable insulation.

c. Megger or Insulation Resistance Test is a simple, short test where DC voltage of 100 to 2500 volts is applied to a cable or winding from a constant source of potential, such as a James G. Biddle Co. megger insulation tester. The voltage is usually considerably below the maximum test value permitted. The insulation resistance is read directly off the indicator and is in megohms. The quality of the insulation is evaluated based on the level of insulation resistance. This test is usually the routine test conducted by the contractor or may be a preliminary test to a more important proof or step voltage test.

d. Dielectric Absorption Test is a constant DC voltage is applied to a winding or cable and time resistance readings are taken. Typically, a 1 minute and a

10 minute reading of insulation resistance are recorded. The 10 minute reading divided by the 1 minute reading yields the polarization index. A polarization index of less than 1.0 is considered a poor reading and usually indicates the need for maintenance before placing into service. The dielectric absorption tests should be conducted at the voltage and time durations as specified by the equipment manufacturer. This test is often used to determine the effects of cleaning and drying operations.

2.14 GROUNDING TABLE

Description of Ground	Resistance to Earth In Ohms		Approved Test Methods
	Desired Value	Max. Accept. Value	
Incoming Line Utility Company Substation Grounds	5		BY UTILITY
Main Generator Ground	5		B
12.47/.480 kV Transformer Grounds	5		B or C
Lightning Arrestors (Station Type)	5		B or C
Lightning Arrestors (Distr. Class)	5		B or C
Building Loops or Steel Stacks, Chimneys, Tanks	5		B or C
Gang Operated Switch Handles	5		B or C
12.47 kV Switchgear Ground Bus	5		B or C
480 Volt Switchgear Ground Bus	5	5	B or C
Distributed Control System - Connected to the Plant Ground Grid	5		B or C

Note: Testing contractor shall notify owner when values specified are not achieved.

APPENDIX 1 ELECTRICAL MANHOLE INSPECTION CHECKLIST

Date: ________________ Drawing Number/Rev_________________________

Installing Contractor: ____

This Checklist is intended as a reference guide which may be used during the inspection of manholes.

INSPECTION PRIOR TO CONCRETE POUR OR DRY PACKING	Initial & Date
1. Check opening size and location for compliance to specifications and drawings.	
2. Conduit windows in correct location and level.	
3. Grounding in place and secure.	
4. Pulling eyes in place.	
5. Inserts in place and provided with fillers.	
6. Check conduit size, orientation, type, and location for compliance to specifications and drawings.	
7. Check conduit for adequate support during pour.	
8. Check conduit openings for plug and/or cap requirements.	
9. Check conduit for proper termination.	
10. Sump or drain provided in accordance with drawings.	
11. Precast structure is level and set at correct elevation.	

INSPECTION AFTER CONCRETE POUR OR DRY PACKING	
1. Conduit entrances free of concrete and clean.	
2. Pulling wires in place.	
3. Cable racks, arms, saddles, and cable tray properly installed.	
4. Rigid steel conduit and all metallic components grounded.	
5. Cable supports free of sharp edges.	
6. Ladders and/or rungs installed.	
7. Conduits swabbed out.	

Comments

____
CM QA Representative/Date

Distribution:

____
Contractor Representative/Date

APPENDIX 2 ABOVEGROUND CONDUIT INSPECTION CHECKLIST

DATE: ____________________ Dwg/Rev.: ______________________________

This Checklist is intended as a reference guide which may be used during the inspection of condui	**Check Item**
1. Supports and spacing in accordance with specifications and drawings.	
2. Supports adjacent to terminal fittings.	
3. Conduits clean, stub-ups protected, open ends plugged, damage during construction repaired.	
4. Field bend radius correct in accordance with specifications and codes. Bends free of deformities.	
5. Expansion joints installed where required.	
6. Installation neat and evenly spaced.	
7. Spacing between instrument and power conduit in accordance with specifications.	
8. Spacing from hot pipes and from hot surface maintained in accordance with specifications.	
9. Conduit permanently and effectively grounded, unless specifications permit otherwise. Bonding jumpers installed around expansion joints.	
10. Proper fittings installed with threads fully engaged, no wrench cuts, conduit ends have bushings and covers installed.	
11. Seals and drains installed where needed.	
12. Aluminum, PVC, or PVC coated conduit installed as specified.	
13. Flexible conduit installed with proper bending radius and with standard fittings.	
14. Junction boxes leveled and supported with proper hubs, locknuts and bushings installed. Junction boxes properly identified.	
15. Adequate number of pulling points.	

Distribution:

____

Contractor/Date:

____

CM QA Representative/Date

APPENDIX 3 CONDUIT SEALING INSPECTION RECORD

Date: ____________________ Rev: _____________________

1. Conduit seals, as shown on the following drawings, poured and marked by Construction. (List drawing numbers or attached drawings with Revs):

	Initial&Date

2. Additional conduit seals, recorded on as-built drawings, poured and marked by Construction for the following: equipment, analyzer housings, local control panels, etc. (List Tag Numbers):

Distribution:

____
Contractor/Date

____
CM QA Representative/Date

APPENDIX 4 CABLE TRAY INSPECTION CHECKLIST

Date: __________________ Drawing/Rev: ___________________

Item	***Initial & Date***
1. Tray size/material in accordance with drawings.	
2. Expansion joints properly installed.	
3. All braces and supports located in accordance with drawings.	
4. Hold-downs properly installed. Tray is anchored only in location shown on drawings.	
5. No sharp edges to cut cable. Hardware assembled with bolt heads flush with inside of tray side rail.	
6. All nonconductive coatings removed at splice joints, ensuring continuity of electrical ground path, or fittings designed to make removal unnecessary.	
7. Field bends or modifications continue to provide electrical ground path and proper support for cables.	
8. Bonding jumpers installed in accordance with drawings.	
9. No obstruction to pulling of cable.	
10. Tray grounded in accordance with drawings and standard practice.	
11. Spacing between power and instrument trays in accordance with specifications.	
12. Spacing from hot (insulated) pipes in accordance with specifications.	
13. All covers, fire stops and partitions installed.	

Comments:

Distribution:

____
Contractor/Date

____
CM QA Representative/Date

APPENDIX 5 CABLE PULLING INSPECTION CHECKLIST

Date: ___________________ Dwg/Rev.: ____________________

	This Inspection Checklist is for cable pulling in conduit and trays.	***Initial & Date***
1	Check that underground conduit has been swabbed-out and any standing water removed.	
2	Verify that mandrel has been pulled through conduits.	
3	Check that cable tray is free of sharp edges and that rigging is adequate to handle cable.	
4	Check that number of pulling points is adequate and the number of bends between pulling points does not exceed specification requirements.	
5	Check cable reel assignments and cutting schedules. Insure that pulling eyes are in place and cable is not pulled from cable jacket.	
6	Check cable voltage rating, minimum pulling temperature and type of pulling compound. ..	
7	Check cable pulling schedule for direction of pull and method of pulling.	
8	Check arrows on medium voltage cable reels for direction of pulling off reel.	
9	Inspect cables for jacket damage. Visually inspect medium voltage cables as it is pulled off the reel to insure that cable is free of surface damage..	
10	Check if Insulation Resistance Test (megger) on medium voltage cables has been performed before pulling.	
11	Check instrument cable for continuity and isolation from drain wire before pulling (250 Volts or less).	
12	Ambient temperature within manufacturer's recommended installation limits (+4 degrees C or higher).	
13	Monitor pulling tension on critical pulls and verify that maximum permitted tension not exceeded in accordance with Engineering supplied tension data.	
14	Check if Insulation Resistance Test (megger) on power and control cables after installation has been performed and recorded..	
15	Check if DC High Potential Test (hypot) on medium voltage cables has been performed and recorded by testing company..	
16	Continuity check instrumentation wire after installation.	
17	Bend radius of trained cable is in accordance with specifications and cable is free of kinks.	
18	Installation is neat and cable lay (random or maintained spacing) in accordance with contract documents.	
19	Spacing between instrumentation cables and power cables is in accordance with specifications and recognized standards..	
20	Cables identified in accordance with specifications and drawings.	
21	Cable ends sealed after cutting. Cable seals inspected for integrity prior to installation.......	

Distribution:

Contractor/Date ___________________

____

____

CM QA Representative/Date

APPENDIX 6 POWER/CONTROL WIRE & CABLE INSULATION RESISTANCE TEST

.

DATE: ____________________________ REV: _____________________________________

TEST EQUIPMENT: _________________ TEST VOLTAGE: __________________________

AMBIENT TEMPERATURE: __________ ° C __________ ° F

Notes

1. ***Perform Insulation Resistance Test (megger) between each conductor and all other conductors and metallic sheath for cables with non-shielded conductors for motor feeder cables above 100A in all areas and 1 Hp in all process areas. Test between each conductor and shield for multiconductor cables with shielded conductors. Record lowest reading for each cable.***

2. ***Use 500 V test set for cable rated 300 to 600 volts.***

3. ***Readings will vary inversely with temperature and cable length. When Project specifies use of temperature correction factors, attach 2nd sheet with computed values. Indicate on each sheet "Measured" or "Temperature corrected."***

Panel No. Circuit No. Feeder No.	Wire Tagging	Cable Rated Voltage	Wire or Cable				Insulation Resistance (megohms)*	Initials
			Quantity	Size	From	To		

* Minimum acceptable Project values:

Cable Rated Voltage	Test Duration	Resistance For Cable Only	Cable / Wire Size Or Amperage (megohms)	Resistance When Cable Connected to Equipment (ohms)

Distribution:

____

Contractor / Date

____

CM QA Representative./.Date

APPENDIX 7 INSTRUMENT WIRE & CABLE INSULATION RESISTANCE TEST

DATE: ___________________________ REV.: _______________________________________

TEST EQUIPMENT: _______________ TEST VOLTAGE: ____________________________

AMBIENT TEMPERATURE: _____________ ° C

Notes:

1. ***Record only the lowest value.***
2. ***MP - Multi-pair cable. SP - Single pair cable.***
3. ***Megger with instruments disconnected.***
4. ***Use 250 Volt (or lower voltage, when specified) range on DC test set.***
5. ***Readings will vary with temperature and cable length.****

Cable or Instrument Number	**MP or SP Type (2)**	**Conductor to Conduit (Single pair non-shielded cables) (megohms)**	**Conductor or to Conductor (megohms) (1)**	**Shield To Conductor or to Shield (megohms) (1)**	**Overall Shield to Shield (Multi-pair cables only) (megohms) (1)**	**Lead and Armor (Multi-pair cables only) (megohms)**	**Shield to Conduit (Single pair cables only) (megohms)**	**Initials/ Date**

* Minimum acceptable Project values:

Distribution:

____
Contractor / Date

____
CM QA Representative./.Date

APPENDIX 8 MEDIUM VOLTAGE CABLE TERMINATION INSPECTION CHECKLIST

Date: ______________ Equipment Tag#: ___________________ Dwg/Rev: _____________________

Project Activity: ________________________________ Audit Activity: _________________________

This Inspection Checklist is for terminations rated greater than 2000 volts. When this work is contracted, inspection may be documented on the Contractor's detailed Inspection Record.

Circuit Number:__________________________________ Drawing: _____________________________

Kit Manufacturer: _______________________________ Kit Number: ___________________

Item	Initial/ & Date
1. Cable size, type, location, installation, and routing in accordance with drawings.	
2. Bend radius in accordance with specifications and cable jacket free of kinks.	
3. Cable termination supports and support spacing in accordance with drawings and specifications.	
4. Installation neat and evenly spaced.	
5. Verify that cable has been fire wrapped in accordance with specifications.	
6. Termination kit / materials installed in accordance with manufacturer's instructions.	
7. Document DC High Potential Test (hypot) FROM testing agency.	
8. Cable terminated in accordance with equipment manufacturer's instructions, including torqueing of bolted connections.	
9. Check phase location and marking: Left to Right, Top to Bottom, or Front to Rear, in accordance with specification requirements.	
ϕA Acceptable _________________	
ϕB Acceptable _________________	
ϕC Acceptable _________________	
10. Metallic Sheaths / Shields grounded in accordance with contract documents.	

Distribution:

Testing Contractor / Date: ____________________

CM QA Representative / Date: ________________

APPENDIX 9 MV UNDERGROUND CABLE SPLICE INSPECTION RECORD

DATE: ______________________________ REV.: ________________

This Inspection Record is for cables rated greater than 2000 volts. When this work is contracted, inspection may be documented on Contractor's detailed Inspection Record.

REFERENCE DWG.: ______________________ SPLICE NO.: ______________________________

SPLICE KIT MANUFACTURER: ____

KIT NO.: _________________________________ CIRCUIT NO.: _____________________________

FROM: __________________________________ TO: ______________________________________

CABLE RATED VOLTAGE: _______________ CABLE TYPE: _____________________________

1. Coordinates (Surveyor complete and initial / date at right)

Trench Number:		
☐A West / East:	South / North:	
☐B West / East:	South / North:	
☐C West / East:	South / North:	
Manhole Number:	Pull Box Number:	

2. Splice Make-up

☐A Acceptable:	
☐B Acceptable:	
☐C Acceptable:	
Neutral Acceptable:	

3. Document DC High Potential Test (hypot) from testing agency.	
4. Shields grounded, as required.	
5. Field changes recorded on as-built drawings.	

Distribution:

Testing Contractor/Date: __________

CM QA Representative/Date: _________

APPENDIX 10 GROUNDING ANODE TESTING TEST RECORD

DATE: ______________ Rev: ____________________________

TEST EQUIPMENT: ________________________ (Note 1) ________________________________ (Note 2)

REFERENCE DRAWING/Rev: ________________________ ________________________________

Notes:

1. ***Record resistance-to-earth for each anode with all other conductors disconnected. Resistance not to exceed: 25 ohms for any single anode.***
2. ***Check continuity from each anode to any test bar or other anode such that the complete grounding loop is tested.***

Rod Number Or Anode Number	Resistance To Earth (ohms)	Ambient Temp. (° C / ° F)	Weather	Taps (✓)	Initial&Date

Distribution:

____
CM QA Representative/Date

____
Testing Agent Representative/Date

APPENDIX 11 GROUND CONTINUITY OF ELEC. EQUIPMENT & GROUND TEST BARS

Date: ________________ Dwg/Rev: __________________

Test Equipment Used: _____________________ Weather(temp, humidity/conditions): ____________

1. ***Electrical equipment bonded to the main grounding system or dedicated ground rod, as indicated on drawings listed below.***
2. ***Measure resistance from grounding wire tap to tagged equipment bus bars, tagged equipment enclosures, and any other points indicated on the drawings. Resistance not to exceed_____ohms.***

Electrical Equipment Tag No.	Drawing	Measured Resistance (ohms)	Initial & Date

Distribution:

____
Testing Contractor / Date

____
CM QA Representative./.Date

APPENDIX 12 PANELBOARDS INSPECTION RECORD

Date: ______________________________ Rev.: ___________________________________

BUILDING: _______ AREA / UNIT: ______ PANELBOARD TAG: _____________

	Initial & Date
1. Receiving Operations / Inspection complete.	
2. Equipment Protection Program instituted and documented.	
3. Check assembly for any missing parts.	
4. Enclosure approved for area classification.	
5. Panelboard circuit schedule filled out.	
6. Correct circuit breaker, fuse size, and location.	
7. Neutral wire correctly color coded.	
8. Grounding installed and connected. Ground Continuity Test Record (Electrical Equipment and Ground Test Bars), completed.	
9. Seals installed (if required)	
10. Check for breather and drain.	
11. Check panel load balance.	
12. Check color coding of branch circuit conductors.	
13. Clean out.	
14. Check mounting and supports.	
15. Fixtures and receptacles are correct type and installed as per drawings.	
16. Fixtures and receptacles on correct circuit.	
17. Nameplate, number of circuits and panelboard location per drawing.	
18. Correct glands installed (i.e., flameproof glands on explosion proof enclosures).	
19. Megger buses including neutral. Record results on Insulation Resistance (Equipment) Test Record. Main disconnect and outgoing circuits should be open.	
20. Equipment Protection Program completed and documented.	
21. Final inspection complete.	

Distribution:

Contractor/Date: __________________

CM QA Representative/Date: __________________

APPENDIX 13 TRANSFORMER INSULATION RESISTANCE TEST RECORD

Date: ___________ Rev.: ________

SUBSTATION No.: TEST EQUIPMENT:

Notes:

1. ***Use 500 volt test set for 600 volt equipment and below, 2500 volt test set for equipment rated 601 - 5000 volts, and 5000 volt test set for equipment rated over 5000 volts.***
2. ***Test voltage to be applied for 1 minute duration and reading taken.***
3. ***Neutral must be disconnected from ground during test.***
4. ***Record temperature of insulating liquid for liquid-immersed transformers, and surrounding air temperature for dry type transformers.***
5. ***Readings will vary inversely with temperature. When Project specifies use of temperature correction factors, attach 2nd sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."***

Equipment Tag No.	**Resistance In (megohms)***						**Pri To Sec**	**Voltage Rating (kV)**	**Pri-Sec or Air**	**Liquid Temp. (° C / ° F)**
	Primary			**Secondary**						
	☐A to G	**☐B to G**	**☐C to G**	**☐A to G**	**☐B to G**	**☐C to G**				

*Minimum acceptable Project values:

<u>Voltage Class</u> **<u>Resistance (megohms)</u>**

____
Tester's Initials Date

Distribution:

____
Contractor/Date

____
CM QA Representative/Date

APPENDIX 14 SWITCHGEAR INSPECTION RECORD

Date: _____________ Rev.: ____________

Substation: ________ Building: __________ Switchgear Tag No.: ______________	**Initial & Date**
1. Test with circuit breakers withdrawn and with circuit breakers in operating position and open. All circuit transformer secondaries must be shorted before testing begins and instrument potential transformers must be racked in, but with fuses removed. ***2. Provide separate reports per switchgear equipment number.***	
1. Receiving Operations / Inspection complete.	
2. Equipment Protection Program instituted and documented.	
3. Check phasing of buses.	
4. Remove shipping supports.	
5. Check and inspect for completeness of all components. Torque bolted joints according to manufacturer's recommendations.	
6. All devices installed such as: ground fault relays, volt meters, ammeters, breakers, fuses, etc. Location and type according to contractor drawings.	
7. Check control wiring (especially Field connections at shipping splits).	
8. Perform Insulation Resistance Test (megger) buses and record on DC High Potential Test (Hypot) Buses, when required by specification.	
9. Perform Insulation Resistance Test (megger) control and potential transformer primary windings, and documented by testing agency, ...	
10. Check control transformer fuses, type and size.	
11. Check potential transformer fuses, type and size.	
12. Check primary and secondary ratings of all transformers including control transformers.	
13. Check for proper grounding / earthing connections at both ends of assembly. Record bonding resistance Ground Continuity Test Record (Electrical Equipment and Ground Test Bars).	
14. Check ground / earth bus bar continuity to ensure connection has been made at shipping split points.	
15. Tagging correct.	
16. Cubicles clean, dry and dust free.	
17. Instruments zeroed.	

18. Space heaters are connected and operable. ☐
19. Insert and remove breaker of same rating in various units to ensure interchangeability. ☐
20. Check continuity of all fuses. Check size and type. ☐
21. Perform circuit breaker tests. ☐
22. Terminals and connections tight and secure. Torque bolted connections. ☐
23. Mainbus and taps (size according to contractor drawing). ☐
24. Insulation Resistance Test (megger) the DC and AC control circuits, main and outgoing control disconnect devices open. Record results on Insulation Resistance Test Record (Power Control Wire and Cable). ☐
25. Check incoming power cables Insulation Resistance Tested (meggered) prior to connection to switchgear, and that results recorded. ☐
26. Check DC High Potential Testing (hypot) of incoming power cables completed, when required by specification, and documented by testing agency. ☐
27. Incoming feeder terminations properly made up. ☐
28. With switchgear energized, tie breaker open; phase out across tie circuit breaker using hot sticks (also applies to generator breakers). ☐
29. Contractor Representative provided service / supervision for this equipment. Contractor test reports attached to this Inspection Record. ☐
30. Equipment Protection Program completed and documented. ☐
31. Final inspection complete. ☐
32. Where applicable verify that site acceptance test has been completed and documented in accordance with manufacturer provided acceptance test procedures. ☐

Distribution:

____
Vendor Field Engineer/Technician Date

____
CM QA Representative/Date

____
Installing Contractor Date

APPENDIX 15 MOTOR CONTROL CENTER INSPECTION RECORD

Date: ________________ Rev.: __________

Substation: ____________ Building: __________ MCC Tag #.: ___________

	Initial / Date
1. Receiving Operations / Inspection complete……	
2. Equipment Protection Program instituted and documented……	
3. Check for missing parts using contractor drawings. Inspect each unit or cubicle for proper nameplate in accordance with approved drawings……	
4. Inspect main bus and bus taps to switches and potential transformers. Torque bolted joints in accordance with manufacturer's recommendations……	
5. Determine that all terminal block connections are secure and properly identified (especially Field connections at shipping splits)……	
6. Manually operate switches and contactors. Check for freedom of all moving parts……	
7. Check nameplate data for switches, contactors, fuses, and relays against approved contractor drawings. Verify contactor auxiliary contacts, normally open / closed according to drawing……	
8. Check for correct sizing of overload relay heaters in accordance with approved drawings……	
9. Protective grounding / earthing is correctly installed and connected to main ground / earth. Verify Ground Continuity Test Record (Electrical Equipment And Ground Test Bars), completed. Check main ground / earth bus for continuity between shipping sections……	
10. Record Insulation Resistance (megger) readings on Insulation Resistance (Equipment) Test Record. Test with disconnect switches connected and open. Test with disconnect switches connected and closed. For the second test, ensure that neutral is disconnected at starters. Reconnect neutral after second test……	
11. Check that power and control cables for each cubicle Insulation Resistance Tested (megger) and that the Insulation Resistance Test Record (Power Control Wire And Cable), is on file……	
12. Spot check overload relays for trip action by injecting current from relay testing equipment in accordance with relay sheets……	
13. Inspect all protective relays and devices for correct settings. Set overload relays in accordance with relay sheets……	
14. Check to see that enclosure space heaters are connected and operable (when applicable), and that MOTOR space heater circuits are functional……	

15. Overload reset button free and functional…………………………………………………

16. Perform functional check of contactor. Use contractor elementary drawing. Observe all Project safety precautions……………………………………………………….................

17. Check timing relays for correct type, size and time setting in accordance with drawings…………………………………………………………………………….........

18. Check control power transformers for correct size, and voltage in accordance with drawings…………………………………………………………………………….........

19. Check main contact pressure, alignment, and for full contact area (high voltage contactors, only)………………………………………………………………………..........

20. Contractor Representative provided service / supervision for this equipment. Contractor test reports attached to this Inspection Record………………………………………………...

21. Equipment Protection Program completed and documented……………………….........

22. Final inspection complete………………………………………………………………

Distribution:

Vendor Field Engineer/Technician/Date

CM QA Representative/Date

Installing Contractor/Date

APPENDIX 16 MCC FEEDER BREAKER (480V) TEST RECORD

Date ____ Dwg/Rev.: __________________________

Equipment Designation: ____

Load Designation: ____

Load (kW/kVA): __________ Voltage: _________ F.L.A.: ____________________________________

CIRCUIT BREAKER MFR: ______________ RATING: _________ SETTING: ______________

CONDUCTOR SIZE: ______________ POWER: ________ GROUND: ____________________

1. Check nameplate data of breaker against approved contractor drawings................
2. Check breaker components for cleanliness..
3. Check mechanical function of breaker. ....
4. Check wiring for proper identification. ....
5. Check conduits / cables for tagging...
6. Check components for identification...
7. Check equipment for conformance to area classification......................................
8. Check installation for seals, breathers, and drains...
9. Verify power conductor continuity...
10. Check that power cable Insulation Resistance Test (megger) is completed and that Insulation Resistance Test Record (Power, Control Wire And Cable), is on file. ....

Distribution:

____
Installing Contractor / Date

____
CM QA Representative / Date

APPENDIX 17 480V MCC BREAKER/CONTACTOR TEST RECORD

Date: ______________________________ Rev.: ______________________________

Equipment Designation: ____

Load Designation: ____

Load (kW / kVA): __________ Voltage: __________ F.L.A.: ______________________

Circuit Breaker Mfr: ____________________ Rating: ______________ Setting: __________

Contractor Mfr: ______________________ Size: ______________________________

Conductor Size: ________ Power: __________ Control: ______________ GROUND: ________

	Initial & Date
1. Check nameplate data of breaker, contactor fuses and relays against approved contractor drawings…………………………………………………………………………………	
2. Check main and auxiliary contacts…………………………………………………………	
3. Check contactor / breaker components for cleanliness……………………………………	
4. Check control fuses, CPT rating and coil voltage…………………………………………	
5. Check mechanical function of contactor and breaker………………………………………	
6. Check wiring for proper identification……………………………………………………..	
7. Check conduits / cables for tagging………………………………………………………...	
8. Check components for identification……………………………………………………….	
9. Check equipment for conformance to area classification…………………………………..	
10. Check installation for seals, breathers and drains…………………………………………..	
11. Verify continuity of all power and control leads…………………………………………...	
12. Check that power cable Insulation Resistance Test (megger) is completed and that Insulation Resistance Test Record (Power Control Wire And Cable), is on file…………...	
13. Complete functional operation check of the control circuit using contract drawings and approved contractor drawings. Close and open the contactor using all control devices…….	

Distribution:

____
Installing Contractor / Date

____
CM QA Representative / Date

APPENDIX 18 480V MCC MOTOR CIRCUIT TEST RECORD

Date: ______________________ Rev.: ______________________

Equipment Designation: ____________________________________
:
Motor Tag #: __________ Voltage: _______ F.L.A.: ______________________

Load
kW / HP: ___________ RPM: ________ S.F.: ______________________

Circuit Breaker Mfr: ______________ Rating: __________ Setting: __________

Starter Mfr: ____________________ Size: ___________ O/L Htr. Size: ________

Conductor Size: ________ Power: ________ Control: __________ Ground: __________

	Initial & Date
1. Check motor starter for cleanliness………………………………………………….……..	
2. Check nameplate data and tagging of motor starter components for conformance to approved contractor drawings…………………………………………………………...	
3. Check conduits and/or cables for correct tagging………………………………..................	
4. Check equipment and installation for conformance to area classification…………………	
5. Check installation for seals, breathers and drains………………………………………..	
6. Check main and auxiliary contacts of breaker and contactors………………………….…...	
7. Manually check mechanical operation of breaker, contactor, O/L relay and O/L reset device………………………………………………………………………………	
8. Check continuity of power and control cables……………………………………………...	
9. Complete functional operation check of the motor control circuit using the contract drawings and approved contractor drawings. Close and open the starter using all control devices………………………………………………………………………………	
10. Verify proper operation of motor winding space heater unit………………………………	
11. Verify completion of activities on Electric Motor - Electrical Activities Inspection Record, Electric Motor Mechanical Activities Inspection Record, prior to motor bump and run-in, in accordance with Electric Motor Run-in Test Record………………………	

Distribution:

____
Installing Contractor / Date

____
CM QA Representative / Date

APPENDIX 19 EQUIPMENT INSULATION RESISTANCE TEST RECORD

Date: ________________ Rev.: ___________

Test Equipment: _________________________________ Substation: ________________

Ambient Temperature: __________ ° C __________ ° F Ref. Spec: __________________

Reference Drawing: _____________________________

1. ***Use 500 Volt test set for 600 Volt equipment and below, 2500 / 5000 Volt test set for equipment rated over 600 Volts.***
2. ***For equipment with solid state control circuits, consult manufacturer's literature for maximum test voltages.***

Switchgear MCC (other)	Insulation Resistance (megohms)*					Rated	Test Voltage (kV)	Voltage (kV)	Initials
	A to G	B to G	C to G	A to B	B to C	C to A			

* Minimum acceptable Project values:

Equipment Voltage Class	**Resistance (megohms)**

Distribution:

____
Testing Contractor / Date

____
CM QA Representative / Date

APPENDIX 20 DC HIGH POTENTIAL TEST RECORD

Rev. _________________

Date: _______________

Substation: ________________ Ref Dwg/Rev: ____

Equipment Description: ____

Weather: _____________ Temp: _______° C ______°F % Humidity: _____ Conditions: _________

Test Equipment Used: ____

1. ***The test voltage shown below shall be reached in 10 equal voltage and time increments.***
2. ***After each voltage increase, the leakage current shall be allowed to stabilize. If the time intervals chosen are of insufficient duration to stabilize the current, the system shall be discharged and the test repeated with new time intervals of greater, but still equal, duration.***
3. ***Record the stabilized leakage current, in microamps, at the end of each time interval.***
4. ***Allow the voltage to remain constant at the full test voltage and record the leakage current every minute for the test duration time shown below.****
5. ***Read test equipment instruction manual prior to using test equipment.***
6. ***When Project specifies the plotting of test results, attach 2nd sheet with separate plot for each phase. Note leakage current, in microamps, on "y" axis. Note step-voltage increase on "x" axis, followed by time, in minutes, for the dielectric absorption portion of the test.***
7. ***All other phases and shields are to be grounded or earthed.***

Voltage Hold Time At Each Step: _____sec

	kV	kV	kV	kV	kV	kV	kV	kV	kV	kV
☐A										
☐B										
☐C										

(Record leakage current in microamps.)

Time at kV	Sec 30	Min 1	Min 2	Min 3	Min 4	Min 5	Min 6	Min 7	Min 8	Min 9	Min 10	Min 11	Min 12	Min 13	Min 14	Min 15

*Maximum acceptable Project values. Engineering to review for acceptance.

Equipment Voltage Class (kilovolts) ____________ Test Voltage (kilovolts) _________________ Test Duration (minutes) _______

Distribution:

____
Tester's Initials / Date

____
CM QA Representative / Date

APPENDIX 21 BATTERY AND BATTERY CHARGER INSPECTION RECORD

DATE: REV:

SUBSTATION: BUILDING: EQUIPMENT TAG NO.:	**Initial & Date**
Note: *When batteries are placed in service while work is still being performed around them, protection should be provided. Metal objects laid or dropped on them could cause a short or an explosion. Tarpaulin, plastic or similar material, should not be used because batteries in service require ventilation.*	
1. Receiving Operations / Inspection complete.	
2. Equipment Protection Program instituted and documented.	
3. Batteries and racks installed and checked for proper mechanical installation, including connections and number of cells.	
4. Batteries filled with electrolyte to proper level and charged in accordance with manufacturer's recommendations.	
5. Lead acid batteries checked with hydrometer for correct specific gravity, in accordance with manufacturer's specifications.	
6. Grounding connection checked. Record readings on Ground Continuity Test Record (Electrical Equipment and Ground Test Bars).	
7. Battery charger checked for proper installation, wiring complete and properly connected.	
8. Charger operates in accordance with manufacturer's recommendations. Current output, voltage, and operation of control components checked.	
9. Check charger nameplate against approved contractor drawings.	
10. Accessory equipment such as: hydrometer, thermometer, special wrenches, and spare electrolyte accounted for.	
11. Batteries, battery racks, and charger cleaned. Terminals and interconnectors covered with protective base.	
12. Test charger for maximum rated output and correct operation, as required by Project specifications.	
13. Booster charge in accordance with manufacturer's instructions.	
14. Set charger for float operation with adjustment of proper float voltage.	
15. Charger marked with float and boost charge voltage limits.	
16. Verify proper operation of low DC voltage relay and alarm contacts. Indicate limits. .	
17. Verify proper operation of AC failure relay and alarm contacts.	
18. Verify ground detection relay or lights operate properly. Verify alarm output relays operate.	

19.	Voltmeters checked, zeroed.	
20.	Ammeters checked, zeroed.	
21.	Fuses and circuit breakers in accordance with contractor drawings.	
22.	Verify operation of charger output failure relay and alarm contacts.	
23.	Contractor Representative provided service / supervision for this equipment. Contractor test reports attached to this inspection record.	
24.	Equipment Protection Program completed and documented.	
25.	Final inspection complete.	

Distribution:

Contractor / Date:

Owners Representative / Date:

APPENDIX 22 MOTORS – ELECTRICAL ACTIVITIES INSPECTION RECORD

Date: Rev:

MOTOR TAG NO.:	**Initial & Date**

Note: ***Inspection of the Mechanical items related to this motor is documented on the appropriate Mechanical Exhibit for the driven equipment with similar Tag Number.***

1. Equipment Protection Program instituted and documented.	
2. Nameplate data agrees with motor list, plan drawings, and one-line.	
3. Motor type is suitable for use in area classification.	
4. Check the power and control cables Insulation Resistance Tested (megger) prior to connection to motor. Check that Insulation Resistance (Rotating Equipment) Test Record is on file.	
5. For induction motors, perform the following motor tests, as required by the specifications, and document on the appropriate forms. For synchronous motors, test in accordance with manufacturer's instructions.	
a. Insulation Resistance (Rotating Equipment) Test Record (megger)	
b. Equipment absorption Ratio And Polarization Index Test Record	
c. DC Proof Test Record...	
or	
d. DC High Potential Test Record	
e. Insulation Resistance Test of Pedestal (when applicable): ___________ ohms	
6. Grounding / earthing conductors installed, connected, and bonded resistance checked from motor frame to ground / earth system tap. Record resistance on Ground Continuity Test Record (Electrical Equipment And Ground Test Bars).	
7. Motor splices and terminations complete. Spare wires (pigtails) on multiple voltage motors properly insulated.	
8. Motor electrical accessories are properly connected and functioning such as space heater, thermocouples, and vibration switches.	
9. Cable gland properly made up.	
10. Bonding jumper installed, when required, across flexible conduit.	
11. Control station nameplate installed.	
12. Covers are installed, bolts and nuts are tightened.	
13. Final inspection complete.	

Distribution:

Contractor / Date:

APPENDIX 23 MOTORS – MECHANICAL ACTIVITIES INSPECTION RECORD

DATE: Dwg/Rev.:

MOTOR TAG NO.:	**Initial & Date**
1. Receiving Operations / Inspection complete.	
2. Equipment Protection Program instituted and documented.	
3. Anchor bolts checked for location, elevation, and orientation prior to setting equipment.	
4. Equipment set and checked for location, elevation, and orientation.	
5. Preliminary alignment completed and documented.	
6. Jackscrews removed and anchor bolt nuts tightened.	
7. Base plate grouting complete and documented when manufactured grouts are required.	
8. Final cold alignment set to manufacturer's tolerance and documented.	
9. Motor electrical activities complete and documented on Electric Motor - Electrical Activities Inspection Record.	
10. Grease or oil checked to assure proper filling.	
11. Field coatings checked	
12. Verify completion of activities on 460 V Motor Circuit (480 V MCC) Test Record and Electric Motor - Electrical Activities Inspection Record, prior to motor bump and run-in, in accordance with Electric Motor Run-in Test Record.	
13. Equipment Protection Program completed and documented.	
14. Final inspection complete. Mechanical punch items cleared.	

Distribution:

Installing Contractor / Date:

CM QA Representative / Date:

APPENDIX 24 MOTORS – RUN IN TEST RECORD

DATE: REV.:

MOTOR TAG NO.: TEST EQUIPMENT: REF. DWG.:

Notes:

1. ***Duration of tests to comply with Project specifications.***
2. ***Complete Electric Motor - Electrical Activities Inspection Record, prior to energizing motor.***

Test		Remarks	Initial & Date
Resistance:	Bonding resistance measured from motor frame to main ground / earth system tap. _______________ ohms		
Voltage:	Actual voltage measured at Motor Control Center _______________ volts		
Rotation Check:	Bump motor or use Rotation meter to verify rotation. Motor should be uncoupled.		
No Load Current:	At beginning of test __________ Amps At end of test __________ Amps		
Temperature of Bearing - Check bearing for high temperature: Before start: ______________ 15 minutes after start: ______________ 30 minutes after start: ______________ 1 hour after start: ______________ 2 hours after start: ______________ 3 hours after start: ______________			
Vibration:	Make visual inspection during run-test. Record any unusual vibration in remarks column.		
Noise:	Record any unusual noise in remarks column.		

APPENDIX 25 ROTATING EQUIPMENT – INSULATION RESISTANCE TEST RECORD

DATE: _______________ Rev: ______

TEST EQUIPMENT: TEST VOLTAGE:

AMBIENT TEMPERATURE: ______ ° C ° F EQUIP. TEMP., IF KNOWN: ______ ° C ° F

HOW KNOWN:

Notes:

1. ***Use 500 Volt test set for 600 Volt equipment and below, 2500 / 5000 Volt test set for equipment rated over 600 Volts.***
2. ***Test duration shall be 1 minute; note if otherwise:***
3. ***Disconnect each phase winding from neutral, wherever practical. If not practical, test may be made on entire winding.***
4. ***Document testing of low voltage and medium voltage equipment on separate sheets.***
5. ***Readings will vary inversely with temperature. When Project specifies use of temperature correction factors, attach 2nd sheet with computed values. Indicate on each sheet "Measured" or "Temperature Corrected."***

Equipment Tag No.	**Insulation Resistance (megohms)***						**Equipment Rated Voltage**	**Initial & Date**
	□A to G	**□B to G**	**□C to G**	**□A to □B**	**□B to □C**	**□C to □A**		

* Minimum acceptable Project values:

Voltage Class	**Resistance (megohms)**

Distribution:

Field Service Engineer/Technician / Date

APPENDIX 26 POWER TRANSFORMERS INSPECTION RECORD

Date: Dwg/Rev.:

	Initial & Date
1. Inspect the control cabinet, control relays, contactors, indicators, and the operating mechanism..........	
2. Look for loose or damaged bushings; loose terminals; and oil leaks..........	
3. Check oil levels in main tanks, tap changer compartment, and bushings..........	
4. Verify that manufacturers product testing is complete and all results documented....	
5. Check all grounding connections. Verify that equipment is identified as per drawings and GSK Requirements..........	
6. Inspect the inert gas system for leakage, power pressure, etc.	

Distribution:

Installing Contractor / Date:

CM QA Representative / Date

APPENDIX 27 AUTOMATIC TRANSFER SWITCHES

DATE: REV:

SUBSTATION: BUILDING: EQUIPMENT TAG NO.:	**Initial & Date**
Note: *Provide the services of a manufacturer-certified specialist to supervise the installation, make adjustments, and perform tests on the automatic transfer switches and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Check lists and Tests used for this project*	
1. Visually inspect the systems.	
2. Ensure the terminations are tight and all ancillary equipment completely installed.	
3. Ensure all overloads are in place.	
4. Perform electrical tests listed in NETA 7.22.3.2.	

Distribution:

Contractor / Date:

Owners Representative / Date:

APPENDIX 28 EMERGENCY POWER ENGINE GENERATORS & DISTRIBUTION SYSTEMS

Date:________________________________ Rev: ______________________________________

Substation: ___________ Bldg: ____________ Equipment Tag No.: ________________

Provide the services of a manufacturer certified specialist to supervise the installation, make adjustments, and perform tests on the engine generators and emergency power switchgear and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

	Initial & Date
1. Visually inspect the systems ……………………………………………………………	
2. Ensure the terminations are tight on power and control wiring ……………………...	
3. Verify all ancillary equipment completely installed …………………………………	
4. Ensure all overloads are in place ……………………………………………………	
5. Verify that generator is set in place …………………………………………………	
6. Verify fuel connections ……………………………………………………………	
7. Verify radiator connections …………………………………………………………	
8. Verify battery connections …………………………………………………………..	
9. Verify exhaust connections …………………………………………………………	
10. Verify block or oil heater connection ………………………………………………	
11. Check and record engine oil level, radiator water level, & battery electrolyte level ...	
12. Piping system test: Complete system test in accordance with respective section …..	
13. Inspect the installation & access/clearance for service & maintenance to ensure it meets the project and manufacturer's requirement. ……………………………….…....	
14. Check lubricating oil for lubricated-type equipment ………………………………..	
15. Check for proper seismic restraints. …………………………………………………	
16. Check that safety valves have correct setting: greater than compressor discharge pressure, but not greater than pressure rating of system components. ………………	
17. Check that all operating controls are set for initial safe operation. ………………….	
18. Testing generator at 50, 75, 100 percent load capacity using load banks at 100 percent power factor. ……………………………………………………...………	

19. Run load test at all loads for 30 minutes recording engine and alternator readings then start, at 15 minutes and at 30 minutes. ……………………………..…………….
20. Simulate operation of all generator safeties such as high oil pressure, low oil pressure, high temperature, over speed, etc. Observe function of safeties under actual manual malfunction situation. ……………………………………………..
21. Check for excessive vibration and noise. Correct problems ……………………….

Distribution:

____
Contractor / Date:

____
Owners Representative / Date:

APPENDIX 29 LIGHTING CONTROLS

General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

DATE: Dwg/Rev.:

MOTOR TAG NO.:	**Initial & Date**
1. Ensure all labeling for all relays/contactors is affixed and accurate................................	
2. Ensure all terminations are tight	
3. Check sensor placement is adequate for required duty..	
4. Ensure adequate access is provided to all relays/contactors, time clocks, etc	
5. Ensure all circuits for the loads are energized and ready for testing	
6. Obtain all time schedules and individual device time-delay settings for all spaces from the Owner..	
7. Test, calibrate, and set all sensing (photocells, motion sensors, etc.) devices................	
8. Verify the correct operation of all control devices (contactors, relays time clocks, BAS interface relays, etc.)..	
10. Check full load current on all breakers serving controlled lighting to ensure that the breaker is not overloaded..	
11. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is not exceeded..	
12. Enter all time schedules per Owner's direction. Individual device time-delay settings are handled as part of the Room/Zone Checkout described in this Section	
13. Validate all interfaces with other systems on a point-by-point basis	

Distribution:

Contractor / Date:

Owners Representative / Date:

APPENDIX 30 FIRE ALARM SYSTEM/EQUIPMENT

Date: ______________________________ Rev: __________________________
Substation: ________ Bldg: ______________ Equipment Tag No.: _______________

Provide the services of a qualified fire alarm specialist to supervise the installation, make adjustments, and perform tests on the fire alarm system and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 28 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

Start-Up Checks: During startup, perform the following checks and any additional checks specified in manufacturer's instructions.

Start-Up Tests: During startup, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

	Initial & Date
1. Ensure all labeling is affixed and accurate	
2. Ensure all terminations are tight.	
3. Batteries and racks installed and checked for proper mechanical installation, including connections and number of cells........	
4. Review that all fire alarm devices as shown on the construction drawings and shop drawings are installed.	
5. Review height and locations of all pull stations and visual alarms to comply with ADA........	
6. Review height and locations of all pull stations and visual alarms to comply with ADA 90 A.	
7. Check that fire alarm system control panel is clear with no trouble or ground faults	
8. Verify all sprinkler flow and tamper switches have been adjusted.	
9. Check wire supervision on all devices........	
10. Check location of all sensors and switches to ensure conformance with requirements. .	
11. Activate all devices, and assure alarms are initiated and resulting response is per the requirements........	
12. Verify interfaces with all other inter-related systems or equipment including BAS, sound systems, security systems, HVAC systems, vertical delivery systems, etc. on a point-by-point basis for all points	
13. Verify sound level in all spaces, with doors and windows closed, is at least 15dBa above ambient level with a minimum level of 85dBa. If voice alarm messages are transmitted, verify that speech is intelligible in all spaces. Perform testing in each space only after all penetrations of partitions have been sealed in accordance with contract requirements........	

14. Verify that visual alarm devices are directly visible throughout egress paths, assembly spaces, public waiting areas, and public toilets. ....
15. Activate high temperature detectors in the elevator machine room. Verify all sequences including elevator shunt off, elevator recall including alternate floors when main floor is in alarm. ....
16. Activate all sprinkler flow switches. Validate that appropriate zone enunciates and alarms sounds. ....
17. For enunciator panels, validate correct graphic and correct identification of all zones. Test the action and interlocks of all override switches as appropriate. ....
18. For Operator Interfaces:

    a) Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical

    b) Output all specified reports for review and approval

    c) Verify the alarm printing and logging is functional and per requirements.................
19. Validate all interfaces with other systems on a point-by-point basis ....
20. Obtain written approval from the Authority Having Jurisdiction (AHJ)........................
21. Training: Train owner's maintenance personnel on procedures and schedules related to start-up. ....

Distribution:

____
Contractor / Date:

____
Owners Representative / Date:

APPENDIX 31 POWER DISTRIBUTION UNITS (PDU)

Date: ________________________________ Rev: _________________________

Substation: ________ Bldg: ______________ Equipment Tag No.: _______________

Provide the services of a manufacturer's certified specialist to supervise the installation, make adjustments, and perform tests on the Power Monitoring System and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project.

Start-Up Checks: During startup, perform the following checks and any additional checks specified in manufacturer's instructions, the panel board checks listed in this section, and the transformer checks listed in this section.

	Initial & Date
1. Inspect equipment for damage and foreign materials.	
2. Check control wiring terminations and plugs for tightness and/or seating.	
3. Check that sub-assemblies and components are secure	
4. Check system for grounds.	
5. Check lamp test functions	
6. Check remote control functions.	
7. Verify remote alarm communication is functioning	
8. Start-Up Tests: During startup, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions, the panelboard tests listed in this section, and the transformer tests listed in this section.	
9. Verify that alarms are in "normal" condition.	
10. Energize unit and verify AC input, and output power.	
11. Check unit alarms and trips	
12. Check remote annunciation of unit alarms and trips	
13. Training: Train owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance	
14. Contractor representative provided service / supervision for this equipment. Contractor test reports attached to this inspection record.	

Distribution:

____

Contractor / Date:

____

Owners Representative / Date:

APPENDIX 32 ELECTRIC DISTRIBUTION POWER MONITORING SYSTEM

Provide the services of a manufacturer's certified specialist to supervise the installation, make adjustments, and perform tests on the Power Monitoring System and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checklists and Tests used for this project. ***Perform the following final checks before start up***

Date: ______________________________ Dwg/Rev.: __________________________

Motor Tag No.: ____

	Initial & Date
1. Ensure all labeling is affixed and accurate..	
2. Ensure all terminations are tight.	
3. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it	
4. Review that all field input and output devices as shown on the construction drawings and shop drawings are installed	
5. Check wire supervision on all devices.	
6. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum.	
7. Check location of all sensors and switches to ensure conformance with requirements ..	
8. Cause activation of all devices, confirm that associated alarms and/or control sequences are initiated and verify that resulting information displayed on the Power Monitoring System is per the requirements.	
9. Verify interfaces with all other inter-related systems.	
10. For annunciator panels, validate correct graphic and correct identification of all zones. Test the action and interlocks of all override switches as appropriate	
11. For Operator Interfaces a) Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical	
b) Output all specified reports for review and approval.	
12. . Verify the alarm printing and logging is functional and per requirements...................	
13. Validate all interfaces with other systems on a point by point basis	
14. Training: Train owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance. Review data in Operating and Maintenance Manuals.	

Distribution:

____

Contractor / Date:

____

Owners Representative / Date:

APPENDIX 33 ROOM/ZONE CHECKOUT

Date: ________________________________ Rev: ___________________________

Substation: ________ Bldg: ______________ Equipment Tag No.: _______________

Contractor shall complete a checklist acknowledging completion of Div. 26 responsibilities for all rooms. Checklist shall include items such as the following as applicable:

Typical Room:

Item	Initial & Date
1. Receptacle covers on, clean and labeled.	
2. Test every receptacle installed or reconnected under this contract with a receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest	
3. Test each receptacle or branch circuit breaker having ground-fault circuit protection to assure that the ground-fault circuit interrupter will operate when subjected to a ground-fault current exceeding 5 mA within 1/40th of a second. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. "TEST" button operation shall not be acceptable as a substitute for this test. Replace receptacles that do not shutoff power within the specified time limit and retest.	
4. Visually and mechanically inspect raceways to include the following: large junction and pull boxes, supports of raceways, & compression type terminations.	
5. Visually inspect the wiring connections and splices in surface wireways. Confirm that splices are adequately insulated and performed using components approved for the quantity of conductors included in the splice	
6. Light fixture in place and clean with lamps installed	
7. All lighting control devices checked for operation and labeling.	
8. Verify that all occupancy sensors are installed according to manufacturer's recommendations to avoid incorrect cycling of light fixtures (motion outside of space causes lights to turn on, air discharging from ceiling registers causes lights to turn on, etc.)	
9. Adjust occupancy sensor time delay according to owner's instructions. Record the adjustment.	
10. Rooms with Fire Alarm devices Fire alarm sensors and enunciators in place and validated.	

Distribution:

____
Contractor / Date:

____
Owners Representative / Date:

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Commissioning of Electrical Systems**
Document Number	**26 08 00**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
Document Owner	**Facilities Electrical Engineering**
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Key Words	**Identification, Warning tape, Warning labels, Miscellaneous**

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2			1.7I-L	Additional documentation requirements	
3			1.10A	Additional contractor responsibilities	
4			2.2A-H	Added Testing Equipment Revisions	
5			3.4	Added Testing Preparation	
6			3.5	Added Testing Requirements	
7			3.6	Added Electrical Systems, Sub-Systems, Equipment Test Procedures	
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PART 1 - GENERAL

1.1 WORK INCLUDED

A. Systems and equipment testing and start-up.

B. Validation of proper and thorough installation of Division 26, 27 and 28 systems and equipment

C. Functional performance testing of electrical systems.

D. Documentation of tests, procedures, and installations.

E. Coordination of Training Events.

F. Generic Start-Up Procedures for electrical systems and equipment.

1.2 RELATED

A. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.

B. Commissioning Authority (CA) shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.

C. This Section outlines the Cx procedures specific to the Division 26, 27 and 28 Contractors. Requirements common to all Sections are specified in Sections 01 91 13 and the Cx Plan.

1.3 SCOPE

A. The following are included in the Scope of Commissioning on this project:

1. Medium Voltage Feeders and Primary Service Feeders
2. Medium Voltage Switchgear
3. Power Transformers
4. Grounding Equipment And Building Grounding System
5. Low Voltage Switchgear/Switchboards
6. Disconnect Switches
7. Circuit Breakers
8. Motor Control Centers
9. Motor Controllers
10. Distribution Dry-Type Transformers
11. Distribution and Branch Circuit Panelboards

12. Automatic Transfer Switches
13. Emergency Power Generators and Distribution Systems
14. Busways
15. Feeders and Large Branch Circuits
16. Branch Circuits and Receptacle
17. Lighting and Lighting Controls
18. Lightning Protection System
19. Fire Alarm System/Equipment
20. Power Distribution Units (PDU)
21. Motors
22. Electric Distribution Power Monitoring System
23. Security System
24. Communications Systems
25. UPS Systems
26. Transient Voltage Surge Suppressors.
27. Manholes.
28. Splices.
29. Conduits.
30. Cable Trays.
31. Medium Voltage Cable.
32. Power/Control Wire and Cable.
33. Battery and Battery Charger Equipment.

1.4 RELATED WORK AND DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Divison-1 Specification sections, apply to work of this section.

B. Commissioning Plan: The Commissioning Plan outlines the commissioning process beyond the construction specification. All Contractor responsibilities are outlined in Specifications. Cx Plan is available to the Contractor to understand the context of their responsibilities but does not define any additional responsibilities of the Contractor.

C. Section 01 91 13 Facility Commissioning: Details the Cx requirements common across all Divisions beginning with the Construction Phase. Focus is on Contractors responsibilities for the Cx process.

D. Section 01 91 14 – Functional Performance Testing Procedures: Provides 'generic' functional performance testing procedures to illustrate the level-of-effort expected during acceptance testing.

E. Section 26 00 00 General Electrical Provisions: References other Sections stipulating Cx requirements.

F. Individual Sections in the various Divisions: Individual sections stipulate installation, start-up, warranty, and training requirements for the system or device.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 91 13 and the Cx Plan.

1.6 REFERENCE STANDARDS

A. National Electric Code (NEC)

B. American Society for Testing and Materials (ASTM)

C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)

D. Illuminating Engineering Society (IES)

E. Institute of Electrical and Electronics Engineers (IEEE)

F. International Electrical Testing Association (NETA)

G. National Electrical Manufacturers Associates (NEMA)

H. National Fire Protection Association (NFPA)

I. Underwriters Laboratory, Inc. (UL)Documentation

J. Refer to Section 01 91 00 for additional Reference Standards

1.7 DOCUMENTATION

A. In addition to the documentation required in Section 01 91 13, Contractor shall provide to the CA the following per the procedures specified herein, in the Cx Plan, and in other Sections of the specification:

1. Short Circuit, Coordination, and Arch Flash Study: CA shall review and recommend approval.
2. Device Evaluation Study.

B. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports should be provided in pdf electronic format.

C. Field Testing Agency Reports: Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in pdf electronic format. These include but are not limited to:

1. Electrical Testing Agency Reports per Division 26.
2. Thermographic Survey Report.
3. Generator Load Bank Testing.
4. UPS Load Bank Testing.

D. Sample of distribution panel and receptacle labeling for approval.

E. Fire Alarm System Approvals and Certifications.

F. Communications Systems Warranty and testing reports.

G. Copies of electrical testing forms and checklists.

H. Copies of all test reports and check lists filled out under 26.08.00.01.

I. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment and systems.

J. Red Line Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final record drawings, which will be created from the red-lined drawings.

K. Operation and Maintenance Data; The contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.

L. Demonstration and Training: The contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four (4) weeks prior to the training session.

1.8 SEQUENCING AND SCHEDULING

A. Refer Section 01 91 13 and the Cx Plan.

1.9 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 13 and the Commissioning Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off meeting. Contractor shall have input in the protocols and all Parties will commit to scheduling obligations. The CA will record and distribute.

1.10 CONTRACTOR RESPONSIBILITIES

A. Refer to Section 01 91 13: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 13. The following are additional responsibilities or notable responsibilities specific to Division 26:

1. Perform Commissioning tests at the direction of the CxA.
2. Attend construction phase controls coordination meetings.
3. Participate in electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
4. Provide information requested by the CxA for final commissioning documentation.

5. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
6. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.
7. Update schedule as required throughout the construction period.
8. Assist the CxA in all verification and functional performance tests.
9. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
10. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
11. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
12. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
13. Participate in, and schedule vendors and contractors to participate in the training sessions.
14. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
15. Electrical equipment including switchgear, panel boards, motor control centers, lighting, receptacles, dimmers and all other equipment furnished under this Division.
16. Emergency generators, ATS switches and emergency power systems.
17. Fire alarm system
18. Lightning protection
19. UPS systems
20. The equipment supplier shall document the performance of his equipment.
21. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
22. Equipment Suppliers
23. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
24. Assist in equipment testing per agreements with contractors.
25. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

1.11 CONSTRUCTION PHASE

A. Coordinate the work of the Electrical Testing Agency and the Cx requirements.

B. Coordinate the checkout of the Fire Alarm System and the approval of the regulatory authorities with the Cx process.

C. Provide skilled technicians qualified to perform the work required.

D. Provide factory-trained and authorized technicians where required by the Contract Documents.

E. Prepare and submit required draft Start-Up Procedures and submit along with the manufacturer's application, installation and start-up information.

F. Provide assistance to the CA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.

G. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.

H. Record Start-up Procedures on start-up procedure forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above. Each task or item shall be indicated with the Party actually performing the task or procedure.

1.12 ACCEPTANCE PHASE

A. Assist CA in functional performance testing. Assistance will generally include the following:

1. Manipulate systems and equipment to facilitate testing (as dictated in Section 01 91 14 and the Cx Plan in some cases this will entail only an initial sample).
2. Provide any specialized instrumentation necessary for functional performance testing.

1.13 EQUIPMENT SUPPLIER RESPONSIBILITIES

A. Refer to Section 01 91 13.

1.14 CONTRACTOR NOTIFICATION AND SCHEDULING

A. Refer to Section 01 91 13.

1.15 START-UP PROCEDURES AND DOCUMENTATION

A. Refer to Section 01 91 13.

1.16 EQUIPMENT NAMEPLATE DATA

A. Refer to Section 01 91 13.

1.17 INDEPENDENT ELECTRICAL TESTING AGENCY

The Independent Electrical Testing Agency shall be provided under the construction specifications and therefore included with the bid. Many of the aspects of the start-up and functional performance testing indicated herein will be accomplished under the respective section and witnessed by the CA at the indicated sample rate. CA will include applicable test results in the functional performance testing record.

1.18 FUNCTIONAL PERFORMANCE TESTING

A. For applicable systems and equipment, Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 01 91 13.

1.19 FPT ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in Section 01 91 14 and in the specification sections applicable to the systems being tested. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device, which in general conform to NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-2003.

1.20 TRAINING

A. Contractors, subcontractor, vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 91 13 and the individual Specifications.

1.21 O&M MANUAL CONTEXT – PREPERATION AND LOGISTICS

A. Refer to Section 01 91 13 and the individual specifications.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply: All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

2.2 TESTING EQUIPMENT

A. Contractor shall provide all instrumentation necessary for tests for which they are responsible. CA will provide standard instrumentation for measuring medium and low voltage electrical voltage, current, power factor, power, and THD. CA will provide receptacle testers for normal and GFI receptacle tests. Contractor shall provide all other instrumentation required to accomplish the specified testing.

B. Infrared Thermographic Scanner Contractor shall provide infrared scanning equipment. Infrared scanning equipment shall be an (or approved equal) thermovision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2°C with a liquid nitrogen reference.

C. Power Quality Metering

1. Contractor shall provide Ideal Industries #61-807 meter or approved equal.

D. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26. A sufficient quantity of two-way radios shall be provided by each contractor.

E. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

F. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

G. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

H. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 START-UP PROCEDURES: GENERAL

A. Part III of this Section outlines ‘generic’ or minimally acceptable Start-Up Procedures (delineated as Start-Up Checks and Start-Up Tests) and individual systems Training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimum or guideline for required Contractor development of Start-Up Procedures. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized. Start-Up Procedures specific to the equipment and systems installed on this project.

3.2 TESTING PROCEDURES

A. Thermographic Scanning

1. The infrared scan shall be made when the equipment is energized and is operating at its normal capacity, unless otherwise noted. It is intended that the scan be made after the equipment has been in full operation; however, the exact time of conducting the scan will be determined by the CA near the completion of the project.
2. Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable to perform all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.
3. All hot spots shall be marked, identified and an infrared thermographic scanning report prepared and furnished to the Owner.
4. The report shall contain infrared photos of trouble spots with temperature readings.
5. All sources of heating problems shall be promptly reported to the Owner for corrective action by the Division 26 contractor.

3.3 PROCEDURES COMMON TO ALL SYSTEMS

A. The following start up verifications/procedures are common to all systems.

1. Checkout shall proceed from devices to the components to the systems.
2. Verify labeling is affixed per spec and visible
3. Verify prerequisite procedures are done.
4. Inspect for damage and ensure none is present.
5. Verify system is applied per the manufacturer’s recommendations.
6. Verify system has been started up per the manufacturer’s recommendations.
7. Verify that access is provided for inspection, operation and repair.
8. Verify that access is provided for replacement of the equipment.
9. Verify the record drawings; submittal data and O&M documentation accurately reflect the installed systems.
10. Verify all gages and test ports are provided as required by contract documents and manufacturer’s recommendations.
11. Verify all recorded nameplate data is accurate.
12. Installation is done to ensure safe operation and maintenance.
13. Verify specified replacement material/attic stock has been provided as required by the Construction Documents.
14. Verify all rotating parts are properly lubricated.
15. Verify all monitoring and ensure all alarms are active and set per Owner’s requirements.

3.4 TESTING PREPERATION

A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.5 TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Electrical contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.6 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TEST PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.

B. Electrical Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 26 Sections "Instrumentation and Control" and "Sequence of Operations" Assist the CxA with preparation of testing plans.

C. Emergency Generator Testing and Acceptance Procedures: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. Electrical Distribution System Testing: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Automatic Transfer Switch
2. Battery Monitoring System
3. Emergency Generator
4. Emergency Power System
5. EPO System
6. Grounding System
7. Lightning Protection System
8. Low Voltage Switchgear
9. Manual Transfer Switch
10. Motor Control Center
11. Panelboard
12. PDU
13. Power Distribution System
14. Power Monitoring/Metering System
15. Switchboard
16. Transformer
17. UPS System

3.7 ELECTRICAL INSPECTION AND TESTING: REFER TO 26 08 00.01

END OF SECTION 26 08 00.01

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Lighting Control Devices**
Document Number	**26 09 23**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
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Rev #	Revision Originator	Revision Date	Sections Revised	Summary of Revisions made	
1	D. Luchaco	07/19	--	Standards Review	

SECTION 260923 - LIGHTING CONTROL DEVICES

1.1 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Faulty operation of lighting control software.
b. Faulty operation of lighting control devices.

B. Warranty Period: Two year(s) from date of Substantial Completion.

1.2 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.3 PRODUCTS

A. Time Switches: Electronic, programmable units.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. TORK – DZS Series
b. Paragon Electric Company – EC70 Series

B. Outdoor Photoelectric Switches: Solid state, with dry contacts, 15-second time delay, and metal-oxide varistor surge protection.

1. Manufacturers: This specification is based on switches by SensorSwitch.

a. SensorSwitch – TS-1 (120V or 277V)

C. Daylight-harvesting switching controls.

1. Description: System operates indoor lighting.

2. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.

a. Lighting control set point is based on two lighting conditions:

1) When no daylight is present.
2) When significant daylight is present (target level).
3) System programming is done with two hand-held, remote-control tools.

3. Electrical Components, Devices, and Accessories:

a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Daylight-harvesting dimming controls.

1. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

a. Lighting control set point is based on two lighting conditions:

1) When no daylight is present (target level).
2) When significant daylight is present.

b. System programming is done with two hand-held, remote-control tools.

2. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with power pack mounted on luminaire, to detect changes in indoor lighting levels that are perceived by the eye.

3. Electrical Components, Devices, and Accessories:

a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
b. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
c. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).

E. Indoor Occupancy Sensors:

1. Wall or ceiling-mounted, solid-state indoor occupancy and vacancy sensors.

a. Passive infrared

1) Manufacturers: SensorSwitch PIR occupancy sensors as the basis for design. Provide the following models in the appropriate application:

a) SensorSwitch – CM-9-RP (ceiling mounting)
b) SensorSwitch – CM-10-RP (ceiling mounting)
c) SensorSwitch - WV-16-RP (wall mounting)

b. Dual technology.

1) Manufacturers: SensorSwitch PIR occupancy sensors as the basis for design. Provide the following models in the appropriate application:

a) SensorSwitch – CM-PDT-RP (ceiling mounting)
b) SensorSwitch - WV-PDT-RP (wall mounting)

2. Automatic Wall Switch Sensor, dual technology sensor mounted in a standard wall switch box with an integral override switch for turning lights off when area is occupied.

a. Manufacturers: SensorSwitch occupancy sensors as the basis for design. Provide the following models in the appropriate application:

1) SensorSwitch – WSD-PDT-P (single switch)
2) SensorSwitch - WSD-PDT-2P-P (dual switch)

3. Separate power pack:

a. Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
b. LED status lights to indicate load status.
c. Plenum rated.
d. Hardwired connection to switch and BAS.

F. High-bay occupancy sensors, solid-state unit.

1. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet (3.7 to 15.2 m).
2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

a. Sensor Switch.

G. Extreme-temperature occupancy sensors, ceiling or surface mounted, solid-state, with a separate power pack.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

a. Sensor Switch, Inc

H. Outdoor Motion Sensors: Luminaire and individually mounted, suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as raintight according to UL 773A.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

a. Sensor Switch, Inc

I. Lighting Contactors: Electrically operated and mechanically held, with fusible switch and interface to connect to BAS.

J. Emergency Shunt Relay: Normally closed, electrically held, arranged for wiring in parallel with manual or automatic switching contacts.

K. Control Cables:

1. Power Cables: Not smaller than No. 12 AWG.
2. Class 2 and 3 Control Cables: Stranded-copper conductors, not smaller than No. 18 AWG.
3. Class 1 Control Cables: Stranded-copper conductors, not smaller than No. 14 AWG.

1.4 INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

END OF SECTION 260923

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Lighting Control Panelboards**
Document Number	**26 09 26**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
Document Owner	**Facilities Electrical Engineering**
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1	D. Luchaco	07/19	--	Standards Review	

SECTION 260926 - LIGHTING CONTROL PANELBOARDS

1.1 PRODUCTS

A. System Description: Signal from field-mounted or onboard signal source opens or closes the electrically operated circuit breakers in the lighting control panelboards.

B. Interface with DDC System for HVAC: Enables DDC system for HVAC to monitor, control, display, and record data.

C. Lighting Control Panelboards: Contains both normal and remotely operated circuit breakers and standard branch circuit breakers. Switching endurance of circuit breakers labeled with SWD and HID ratings not less than 50,000 full-load operations.

D. Surge Protective Devices: UL 1449, Type 1.

E. Circuit Breakers: UL 489 SWD, 50,000 full-load open/close/open remote operations.

1.2 MAIN CONTROLLERS

A. Description: Controllers shall contain the power supply and electronic control for operating and monitoring remotely operated branch circuit breakers.

1. Comply with UL 916; with a microprocessor-based, solid-state, 365-day timing and control unit.
2. Power Supply: Powered from the panelboard, sized to provide control power for the operation of the remotely operated circuit breakers, controller, bus system, low-voltage inputs, field-installed occupancy sensors, and low-voltage photo sensors.
3. Integral keypad and digital-display front panel for local setup, including the following:

    a. Blink notice, time adjustable from software.
    b. Ability to log and display remotely operated breaker-on-time.
    c. Upgradeable firmware, so that the latest production features may be added in the future without replacing the module.

4. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation.
5. Ethernet Communications: Comply with ASHRAE 135 protocols.

    a. Each input connected to the controller shall control any remotely operated breaker in any other networked lighting control panel.
    b. A schedule programmed at one controller shall be able to control any remotely operated breaker in any other networked lighting control panel.

6. Time Synchronization: The timing unit shall be updated not less than every 12 hour(s) with the network time server.

7. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard Web browser.

8. Alarm and E-mail Notification: Automatically initiate alarms based on preconfigured conditions listed below and routing alarm alerts as set at the control panel.

B. Timing Unit:

1. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
2. Clock configurable for 12-hour (a.m./p.m.) or 24-hour format.
3. 16 independent schedules, each having 24 time periods.
4. Schedule periods settable to the minute.
5. Day of week, day of month, day of year with one-time or repeating capability.
6. 32 special date periods.

C. With eight inputs, each configurable to the following parameters:

1. NO, NC, two-wire maintained toggle, two-wire momentary toggle, two-wire momentary on, two-wire momentary off, or three-wire momentary operation.
2. On- and off-delay timers for local override operation, adjustable from five minutes to 12 hours. Local override shall be by field-installed, two-wire momentary toggle switch.

1.3 SLAVE PANEL CONTROLLERS

A. Slave panels shall contain the necessary busses and network hardware to allow connection of the sub-net wiring between panels, with programming at the main panel controller. Programmable timing unit, Web server, alarm and e-mail notification, and Ethernet connection to the control network is not required, provided all of these functions are available for the slave panel from the main lighting panel controller.

B. Sub-net wiring connections shall allow connection of wiring to a terminal that can be removed from the panel without interrupting communications to other panels.

C. Slave panels shall contain a nameplate label attached to the deadfront trim indicating the panel designation, panel network address, and panel designation of the associated master panel.

1.4 CONTROL NETWORK

A. Panel Controllers: Networked with other lighting control system controllers in a peer-to-peer configuration using Ethernet 100Base-T network.

B. Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

1.5 MANUAL SWITCHES AND PLATES

A. Keypads: Programmable and designed to control lighting applications and functions associated with the equipment of this Section. The units shall be able to control any system output device, including remotely operated circuit breakers, relays, dimmers, and analog outputs.

B. Push-Button Switches: Modular, momentary-contact, low-voltage type.

1. Match color specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

C. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 262726 "Wiring Devices."

D. Wall Plates: Single- and multigang plates as specified in Section 262726 "Wiring Devices."

E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

1.6 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 and Class 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 22 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 6, for horizontal copper cable. Comply with requirements in Section 271500 "Communications Horizontal Cabling."

1.7 INSTALLATION

A. Comply with NECA 1.

1.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections

END OF SECTION 260926

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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1	D. Luchaco	07/19	--	Standards Review	

SECTION 260933 - CENTRAL DIMMING CONTROLS

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain central dimming controls from a single source with total responsibility for compatibility of lighting control system components specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.2 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:

1. Division 26 Section "Lighting Control Devices."

1.3 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Damage from transient voltage surges.

2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

1.4 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.5 SYSTEM DESCRIPTION

A. Compatibility:

1. Dimming control components shall be compatible with luminaires, ballasts, and transformers.
2. Dimming control devices shall be compatible with lighting control system components.
3. Dimming control devices shall be compatible with local building management system.

B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.

1. Alternative Line-Voltage Surge Suppression: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" for Category A locations.

C. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

1.6 DIMMING CONTROLS

A. Description: Microprocessor-based, solid-state controls consisting of master-control station(s), wall stations, and dimmer panels; and a separately mounted dimmer cabinet.

1. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a rocker switch is operated or enabled.
2. Each zone shall be configurable to control the following light sources:

   a. Fluorescent lamps with electronic ballasts.
   b. LED lamps.
   c. Incandescent lamps.
   d. Cold cathode lamps.
   e. Non-dimmed loads.

3. Control of each zone shall interface with controls for the following accessory functions:

    a. Curtains and drapes.
    b. Blackout curtains.
    c. Projector screens.
    d. Motorized partitions.
    e. Manually positioned partitions.

4. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.

1.7 TOUCHSCREEN CONTROLS

A. Description: Backlit, color, LCD, touchscreen with 640 by 480 SVGA resolution with 16-bit color graphics. Capable of displaying high resolution media and text.

B. Master-Control Station Screen Size: 5.7 inches (145 mm).

C. Partitioned-Space Master-Control Station Screen Size: 5.7 inches (145 mm).

D. Wall-Station Screen Size: 5.7 inches (145 mm).

E. Control Option: Backlit, push-button controls for on-screen menu navigation with custom engraving.

F. Control Option: Software-defined controls for on-screen menu navigation.

G. Mounting Location: Wall, Rack, or Lectern. Refer to drawings.

H. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices." Master-control cover plate shall be one piece.

I. Powerpack: 120-V ac.

J. Communications: Ethernet.

1.8 KEYPAD CONTROLS

A. Description: Field configurable, backlit keypad with customized, engraved buttons capable of controlling preset lighting scenes.

B. Mounting: Single, flush wall box.

C. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices", with hinged transparent locking cover.

1.9 CONTROL NETWORK

A. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.

B. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.

1. Control Voltage: 24- or 10-V dc.
2. Comply with ESTA E1.11/USITT DMX 512-A for data transmission.
3. Communications: Ethernet.

1.10 MASTER-CONTROL STATIONS

A. Functions and Features:

1. Control adjustment of the lighting level for each scene of each zone, and adjustment of fade-time setting for each scene change from one preset scene to another. Controls shall use digital rocker switches with LCD graphic display of light level.
2. Master channel shall raise and lower lighting level of all zones.
3. Fade rate for each scene shall be adjustable from zero to 60 seconds.
4. Fade override control for each scene.
5. Recall each preset scene and allow adjustment of zone controls associated with that scene.
6. Lockout switch to prevent changes when set.
7. On and off scene controls for non-dim channel contactors.
8. Emergency-control push button to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
9. Master on and off switch; off position enables housekeeping controls.
10. Housekeeping controls to turn on selected luminaires for housekeeping functions.
11. Controls for accessory functions.
12. Enable and disable wall stations.
13. Communications link to other master stations.
14. Provide interface to program the master station.
15. Rear-illuminate all permanent controls.
16. Indicate lighting-level setting and fade-rate setting graphically.
17. Native communication with building audiovisual system.
18. BAS interface.

B. Mounting: Single, flush wall box.

C. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices", with hinged transparent locking cover.

1.11 PARTITIONED-SPACE MASTER-CONTROL STATION

A. Functions and Features:

1. Preconfigured lighting controller with manual and software setup.
2. Automatically combine and separate lighting and accessory function controls as spaces are configured with movable partitions; with controls for adjustment of the lighting level for each scene of each dimmer, and adjustment of fade-rate setting for each scene change from one preset scene to another.
3. Master controls shall accommodate partitioning the space into six adjacent rooms.
4. Manual controls to set up six scenes for each room. Include wall stations in each room to control scenes.
5. Master channel to raise and lower the lighting level of all zones.
6. Adjustable fade rate for each scene from zero to 60 seconds.
7. Fade override control for each scene.
8. On and off scene controls for non-dim channel contactors.
9. Emergency-control push button to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
10. Master on and off switch; off position enables housekeeping controls.
11. Housekeeping controls to turn on selected luminaires for housekeeping functions.
12. Controls for accessory functions.
13. Provide interface to program the master station.
14. Rear-illuminate all permanent controls.
15. Indicate lighting-level setting and fade-rate setting graphically.
16. Native communication with building audiovisual system.
17. BAS interface.

B. Custom Graphics. Include a graphical display of room configurations and the names for each. Indicate the current spaces configuration with LCD graphic or LED-illuminated indicators, and show which wall stations are active. Inactive wall stations shall be automatically deactivated.

C. Mounting: Single, flush wall box.

D. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices", with hinged transparent locking cover.

1.12 WALL STATIONS

A. Functions and Features:

1. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.
2. Touchscreen controls to adjust the lighting level of each dimmer for each scene, and the fade time setting for each scene change from one preset scene to another.
3. Numbered push buttons to select scenes.
4. Off switch to turn master station off.
5. On switch turns all scenes of master station to full bright.
6. Push-button controls for accessory functions.

B. Mounting: Flush, wall box.

C. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices."

D. Hand-Held Cordless Control: Scene-select and accessory function push buttons using infrared or radio-frequency transmission.

1.13 DIMMER CABINETS

A. Factory wired, convection cooled without fans, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.

B. Ambient Conditions:

1. Temperature: 60 to 95 deg F (15 to 35 deg C).
2. Relative Humidity: 10 to 90 percent, noncondensing.
3. Filtered air supply.

C. Dimmer Cabinet Assembly: Listed and labeled by an NRTL for intended use.

D. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.

1. Integrated Fault-Current Rating: refer to drawings.

E. Lighting Dimmers: Solid-state SCR dimmers.

1. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.
2. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IES's "IES Lighting Handbook."
3. Dimming Range: Zero to 100 percent, full output voltage not less than 98 percent of line voltage.
4. Dimmed circuits shall be filtered to provide a minimum 350-microsecond current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/microseconds, measured from 10 to 90 percent of load-current waveform.
5. Protect controls of each dimmer with a fuse and surge protective device.

F. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.

G. Accessory function control modules shall be compatible with requirement of the accessory being controlled.

H. Digital Control Network:

1. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
2. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.

I. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.

1. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
2. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
3. Integrated Fault-Current Rating: Same value as listed for the panel.
4. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
5. Fabricate and test dimmer boards to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.14 REMOTE PROGRAMMING

A. Description: Web-browser-based interface to program master station and associated wall stations and all interconnected master stations.

B. Software shall be configured and customized by master-station manufacturer. Software shall be updated to latest release available at time of installation.

C. Interface shall be protected by unique username and password combination with authentication scheme complying with Owner's network security requirements.

1.15 MANUAL SWITCHES AND PLATES

A. Switches: Modular, momentary push-button, low-voltage type.

1. Color: White unless otherwise indicated; red when associated with emergency circuits.
2. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
3. Locator Light: Internal illumination.
4. Wall Plates: Comply with requirements in Section 262726 "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

1.16 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

D. Unshielded, Twisted-Pair Data Cable: Category 6. Comply with requirements in Division 27 Section "Communications Horizontal Cabling."

1.17 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: In raceways.

1.18 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

END OF SECTION 260933

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards
For Use At S&T/WPS Facilities.

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1	D. Luchaco	07/19	--	Standards Review	

SECTION 260936 - MODULAR DIMMING CONTROLS

1.1 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multi-preset modular dimming controls that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Damage from transient voltage surges.

2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.

B. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges

1.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Lutron Electronics Inc.

1.3 SYSTEM DESCRIPTION

A. Compatibility:

1. Dimming control components shall be compatible with luminaires, ballasts, and transformers.

B. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and RFI Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules shall include integral or external filters to suppress audible noise and RFI.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

C. Capacities: Unit shall be rated for 2400 W at 240-V ac and 2000 W at 120-V ac for up to 100 devices or zones.

D. Surge Protection: Withstand supply power surges without impairment to performance.

1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.

E. Off Control Position: User-selected off position of any control point shall disconnect the load from line supply.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.4 WALL-BOX MULTISCENE DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in multigang wall box under a single wall plate. Each zone shall be adjustable to indicated number of scenes, which shall reside in the memory of zone controller.

B. Dimmers: Each zone shall be configurable to control the following loads:

1. Fluorescent lamps with electronic ballasts.
2. LED lamps.
3. Incandescent lamps.
4. Low-voltage lamps, derived with magnetic transformers.
5. Non-dim, on-off switching only.

C. Dimmers: Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of rms voltage.

D. Memory:

1. Retain preset scenes and fade rates through momentary (up to 3-second) power interruptions.
2. Retain preset scenes through power failures for at least seven days.

E. Device Plates: Style, material, and color shall comply with Standard 26 27 26 "Wiring Devices." Master-control cover plate shall be one piece.

F. Master controller shall include the following:

1. Cover-mounted switches, including master off, all bright, and selectors for each scene.
2. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
3. Concealed switches and indicators for specified function.
4. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
5. Fade time indicated by digital display for current scene while fading.
6. Cover-mounted infrared receiver.

G. Infrared Transmitters: Wireless remote control for recalling each of the presets. Operate up to 50 feet (15 m) within line of sight of the master controller.

1.5 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Standard 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

1.6 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with requirements in Standard 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch (13 mm).

1.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

END OF SECTION 260936

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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1	D. Luchaco	07/19	--	Standards Review Updates	

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

1.1 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL

1.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70 and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.

C. Coils: Continuous windings without splices except for taps.

1. Coil Material: Aluminum or copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

E. Enclosure: Ventilated.

1. NEMA 250, Type 2 / Type 3R: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.

2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.

   a. Finish Color: Gray weather-resistant enamel.

F. Enclosure: Ventilated.

1. NEMA 250, Type 4X, Stainless Steel: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.

G. Taps for Transformers 3 kVA and Smaller: None.

H. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

J. Insulation Class, Smaller than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rises above 40 deg C ambient temperature.

K. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

L. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

M. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

N. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

O. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

P. Wall Brackets: Manufacturer's standard brackets.

Q. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91.

1.4 IDENTIFICATION

A. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems.

1.5 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Secure transformer to concrete base according to manufacturer's written instructions.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

G. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

1.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Remove and replace units that do not pass tests or inspections and retest as specified above.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

1.7 FIELD QUALITY CONTROL

A. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

END OF SECTION 262213

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Low-Voltage Buck-Boost Transformers**
Document Number	**26 22 16**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
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SECTION 262216 - LOW-VOLTAGE BUCK-BOOST TRANSFORMERS

1.1 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Energy Efficiency:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

1.2 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer.

1. Transformers shall be listed and labeled as complying with UL 1561 and UL 5085.

B. Standard Impedance at 60 Hz: 2 to 5 percent (up to 10 kVA).

C. Nameplate Rating: Linear load, 60 Hz.

D. Insulation Class: 220 deg C system.

E. Temperature Rise: 150 deg C.

F. Core Construction: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
2. Grounded to enclosure.

G. Coil Conductors: Continuous aluminum or copper windings, with terminations brazed, welded, or bolted.

H. Encapsulation: Transformers shall have core and coils completely resin encapsulated.

I. Terminations: Transformer coils shall terminate in mounting pads. Mounting lugs shall be provided on all units up to and including 270-A ratings.

J. Antivibration pads or isolators shall be used between the transformer core and coil and the enclosure.

K. Ground core and coil assembly to enclosure with a flexible copper grounding strap or equivalent.

L. Mounting:

1. Ventilated Units up to 750 lb. (340 kg): Suitable for wall, floor, or ceiling mounting (drip plate required).
2. Ventilated Units over 750 lb. (340 kg): Suitable for floor mounting only.
3. Encapsulated Units up to 285 lb. (130 kg): Suitable for wall or floor mounting.
4. Encapsulated Units over 285 lb. (130 kg): Suitable for floor mounting only.

M. Enclosure:

1. Ventilated.
2. NEMA 250, Type 2; NEMA 250, Type 3R; NEMA 250, Type 4X.
3. Finish Color: Gray ANSI 49 gray weather-resistant enamel. Stainless steel shall not be painted.

N. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9.00 kVA and less: 40 dBA.
2. 9.01 to 30.00 kVA: 45 dBA.
3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 1, 4, and 9, 48 dBA for K-factors of 13 and 20.

1.3 IDENTIFICATION

A. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

1.4 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Secure transformer to concrete base according to manufacturer's written instructions.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

G. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

1.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Remove and replace units that do not pass tests or inspections and retest as specified above

1.6 FIELD QUALITY CONTROL

A. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

END OF SECTION 262216

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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1	D. Luchaco	07/19	--	Standards Review	

SECTION 262413 - SWITCHBOARDS

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain switchboards, over current protective devices, components, and accessories from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 2.

D. Comply with UL 891.

1.2 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.3 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include to the following:

1. Square D; a brand of Schneider Electric.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

D. Front- and Rear-Accessible Switchboards:

1. Main Devices: Drawout mounted.
2. Branch Devices: Fixed and individually compartmented mounted.

a. Sections front and rear aligned.

E. Nominal System Voltage: Project specific, refer to drawings.

F. Main-Bus Continuous: Project specific, refer to drawings.

G. Indoor Enclosures: Steel, Type 1.

1. Finish: Standard gray color.

H. Outdoor Enclosures: Type 3R, furnish with interior-lighted walk-in aisle where noted on drawings.

1. Finish: Standard.
2. Enclosure: Downward, rearward sloping roof; rear hinged doors, with provisions for padlocking.
3. Doors: 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking.
4. Accessories: LED luminaires, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack luminaire installed on wall of aisle midway between personnel doors.
5. Walk-in aisle heating and ventilating.

I. Barriers: Between adjacent switchboard sections.

J. Insulation and Isolation: Main bus of main section and main and vertical buses of feeder sections.

K. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in switchboard.

L. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

M. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

N. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

O. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

P. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

Q. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

R. Buses and Connections: Three phase four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity.
2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
3. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

S. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

T. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

1.4 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Square D; a brand of Schneider Electric.

B. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, plug-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
10. Four-digit, transient-event counter set to totalize transient surges.

C. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

D. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

E. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277, 208Y/120, 600Y/347-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
2. Line to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
3. Neutral to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.

F. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

1. Line to Neutral: 400 V, 800 V from high leg.
2. Line to Ground: 400 V.
3. Neutral to Ground: 400 V.

G. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

1. Line to Line: 2000 V for 480 V, 1000 V for 240 V, 2500 V for 600 V.
2. Line to Ground: 1500 V for 480 V, 800 V for 240 V, 2500 V for 600 V.

1.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    h. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Drawout circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time time adjustments.
    c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 125-V dc.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Boltswitch, Inc.
    b. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    c. Pringle Electrical Manufacturing Company, Inc.
    d. Siemens Energy & Automation, Inc.
    e. Square D; a brand of Schneider Electric.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

    a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
    b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
   c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
   d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

1.6 INSTRUMENTATION

A. Refer to Section 262713, "Electricity Metering" for requirements for electric meter to be installed in switchboards indicated on the Electrical Single Line Diagrams.

B. Instrument Transformers: NEMA EI 21.1, IEEE C57.13.

1.7 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

1.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for over current protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

D. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

1.9 IDENTIFICATION

A. Refer to Section 260553, "Identification for Electrical Systems". Identify units, devices, controls and wiring.

1.10 INSTALLATION

A. Install switchboards and accessories according to NECA 400.

B. Comply with NECA 1.

1.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests: Infrared scanning, ground-fault protection, and NETA ATS.

END OF SECTION 262413

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Panelboards**
Document Number	**26 24 16**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
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1	D. Luchaco	05/17/19	--	Standards Review	

SECTION 262416 - PANELBOARDS

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, over current protective devices, components, and accessories from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

1.2 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.3 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Finishes:

a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pre-treating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized steel.

7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
5. Split Bus: Vertical buses divided into individual vertical sections.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Sub feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and over current protective devices.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

1.4 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

1.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same the short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

1.6 LOAD CENTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Square D; a brand of Schneider Electric.

B. Load Centers: Comply with UL 67.

C. Mains: Circuit breaker or Lugs only.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

1.7 ELECTRONIC-GRADE PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

F. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
2. Copper equipment and isolated ground buses.

G. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.

1. Accessories:

a. Fuses rated at 200-kA interrupting capacity.
b. Fabrication using bolted compression lugs for internal wiring.
c. Integral disconnect switch.
d. Redundant suppression circuits.

e. Redundant replaceable modules.
f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
g. LED indicator lights for power and protection status.
h. Audible alarm, with silencing switch, to indicate when protection has failed.
i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
j. Four-digit, transient-event counter set to totalize transient surges.

2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.

   a. Line to Neutral: 70,000 A.
   b. Line to Ground: 70,000 A.
   c. Neutral to Ground: 50,000 A.

4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
5. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277, 208Y/120, 600Y/347-V, three-phase, four-wire circuits shall be as follows:

   a. Line to Neutral: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
   b. Line to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
   c. Neutral to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.

6. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:

   a. Line to Neutral: 400 V.
   b. Line to Ground: 400 V.
   c. Neutral to Ground: 400 V.

7. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

   a. Line to Neutral: 400 V, 800 V from high leg.
   b. Line to Ground: 400 V.
   c. Neutral to Ground: 400 V.

8. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

   a. Line to Line: 2000 V for 480 V, 1000 V for 240 V, 2500 V for 600 V.
   b. Line to Ground: 1500 V for 480 V, 800 V for 240 V, 2500 V for 600 V.

1.8 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I^2t response.

   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
   6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
   7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
   8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
      c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
      d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      e. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
      f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
      g. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.

h. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
k. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
l. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."
2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
3. Auxiliary Contacts: One normally open and normally closed contact(s) that operate with switch handle operation.

1.9 PANELBOARD SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Liebert Corporation.
2. Square D; a brand of Schneider Electric.

B. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:

a. LED indicator lights for power and protection status.
b. Audible alarm, with silencing switch, to indicate when protection has failed.
c. One set of dry contacts rated at 5A and 250-V ac, for remote monitoring of protection status.

C. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in, solid-state, parallel-connected, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:

    a. Fuses rated at 200-kA interrupting capacity.
    b. Fabrication using bolted compression lugs for internal wiring.
    c. Integral disconnect switch.
    d. Redundant suppression circuits.
    e. Redundant replaceable modules.
    f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
    g. LED indicator lights for power and protection status.
    h. Audible alarm, with silencing switch, to indicate when protection has failed.
    i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
    j. Four-digit, transient-event counter set to totalize transient surges.

2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.

    a. Line to Neutral: 70,000 A.
    b. Line to Ground: 70,000 A.
    c. Neutral to Ground: 50,000 A.

4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
5. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277, 208Y/120, 600Y/347-V, three-phase, four-wire circuits shall be as follows:

    a. Line to Neutral: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
    b. Line to Ground: 800 V for 480Y/277 400 V, for 208Y/120 1200 V, for 600Y/347.
    c. Neutral to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.

6. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:

    a. Line to Neutral: 400 V.
    b. Line to Ground: 400 V.
    c. Neutral to Ground: 400 V.

7. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

    a. Line to Neutral: 400 V, 800 V from high leg.
    b. Line to Ground: 400 V.
    c. Neutral to Ground: 400 V.

8. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

    a. Line to Line: 2000 V for 480 V, 1000 V for 240 V, 2500 V for 600 V.
    b. Line to Ground: 1500 V for 480 V, 800 V for 240 V, 2500 V for 600 V.

1.10 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate the installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems.

1.11 INSTALLATION

A. Install panelboards and accessories according to NECA 407.

B. Comply with NECA 1.

1.12 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

END OF SECTION 262416

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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1	D. Luchaco	07/19	--	Standards Review	

SECTION 262419 - MOTOR-CONTROL CENTERS

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

1.2 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace TVSS and VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion

1.3 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ABB; Control Products.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Industrial Systems.
4. Rockwell Automation, Inc.; Allen-Bradley Brand.
5. Siemens Energy & Automation, Inc.; Power Distribution.
6. Square D; a brand of Schneider Electric

1.4 SYSTEM DESCRIPTION

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)

3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application

1.5 CHARACTERISTICS AND RATINGS

A. Wiring: NEMA ICS 18, Class I, Type B, for starters above Size 3, Type B-D, for starter Size 3 and below.

B. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

C. Nominal System Voltage: Project specific, refer to drawings.

D. Short-Circuit Current Rating for Each Unit: Project specific, refer to drawings.

E. Short-Circuit Current Rating of MCC: Fully rated with its main over current device; 65 kA.

F. Environmental Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
3. Humidity Rating: Less than 95 percent (non-condensing).
4. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.

G. Main-Bus Continuous Rating: Project specific, refer to drawings.

H. Vertical-Bus Minimum Continuous Rating: Project specific, refer to drawings.

I. Horizontal and Vertical Bus Bracing (Short-Circuit Current Rating): Match MCC short-circuit current rating.

J. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends. Brace bus extensions for busway feeder bus.

K. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.

L. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver plated.

M. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

N. Ground Bus: Minimum size required by UL 845, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit equipment grounding conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

O. Front-Connected, Front-Accessible MCCs:

1. Main Devices: Drawout mounted.
2. Controller Units: Drawout and fixed mounted.
3. Feeder-Tap Units: Drawout and fixed mounted.
4. Sections front and rear aligned.

P. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic MCC. Provide service entrance label and necessary applicable service entrance features.

Q. Owner Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

R. Bus Transition and Incoming Pull Sections: Matched and aligned with basic MCC.

S. Pull Box on Top of an MCC:

1. Adequate ventilation to maintain temperature in pull box within same limits as MCC.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers forming top, front, and sides. Top covers at rear easily removable for drilling and cutting.
4. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
5. Cable supports arranged to facilitate cabling and adequate to support cables, including those for future installation.
6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of unit.

U. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

1.6 FUNCTIONAL FEATURES

A. Description: Modular arrangement of main units, controller units, control devices, feeder-tap units, instruments, metering, auxiliary devices, and other items mounted in vertical sections of MCC.

B. Controller Units: Combination controller units.

1. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
2. Equip units in Type B and Type C MCCs with pull-apart terminal strips for external control connections.

C. Feeder-Tap Units: Through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

D. Future Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

E. Spare Units: Installed in compartments indicated "spare."

1.7 INCOMING MAINS

A. Incoming Mains Location: Top and bottom.

B. Main Lugs Only: Conductor connectors suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.

C. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    h. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
    j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

D. Insulated-Case Circuit Breaker: 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Drawout circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time time adjustments.
    c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 125-V dc.

1.8 COMBINATION CONTROLLERS

A. Reduced-Voltage, Solid-State Controllers:

1. General Requirements for Reduced-Voltage, Solid-State Controllers: Comply with UL 508.
2. Reduced-Voltage, Solid-State Controllers: An integrated unit with power Scars, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium-induction motors.

   a. Configuration: Severe duty; reversible.
   b. Starting Mode: Voltage ramping, current limit, Torque control, Torque control with voltage boost; field selectable.
   c. Stopping Mode: Coast to stop, Adjustable torque deceleration, Adjustable braking; field selectable.
   d. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the Scars. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
   e. Shorting and Input Isolation Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors.
   f. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
   g. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
   h. SCR bridge shall consist of at least two Scars per phase, providing stable and smooth acceleration without external feedback from the motor or driven equipment.
   i. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:

      1) Adjusting motor full-load amperes, as a percentage of the controller's rating.
      2) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
      3) Adjusting linear acceleration and deceleration ramps, in seconds.
      4) Initial torque, as a percentage of the nominal motor torque.
      5) Adjusting torque limit, as a percentage of the nominal motor torque.
      6) Adjusting maximum start time, in seconds.
      7) Adjusting voltage boost, as a percentage of the nominal supply voltage.
      8) Selecting stopping mode, and adjusting parameters.
      9) Selecting motor thermal-overload protection class between 5 and 30.
      10) Activating and de-activating protection modes.
      11) Selecting or activating communications modes.

   j. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:

1) Controller Condition: Ready, starting, running, stopping.
2) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
3) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor under load, over current, shorted Scars, line or phase loss, phase reversal, and line frequency over or under normal.

k. Controller Diagnostics and Protection:

1) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller over temperature and motor overload alarm and trip; settings selectable via the keypad.
2) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under load conditions; and line frequency over or under normal.
3) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
4) Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

l. Remote Output Features:

1) All outputs pre-wired to terminal blocks.
2) Form C status contacts that change state when controller is running.
3) Form C alarm contacts that change state when a fault condition occurs.

m. Optional Features:

1) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc and 4 to 20-mA dc.
2) Additional field-assignable Form C contacts for alarm outputs.
3) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
4) Full-voltage bypass contactor operating manually, with NORMAL/BYPASS selector switch. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.

B. Disconnecting Means and OCPDs:

1. Fusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.

2. MCP Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. NC alarm contact that operates only when MCP has tripped.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
e. NC alarm contact that operates only when MCCB has tripped.

4. Molded-Case Switch Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
d. NC alarm contact that operates only when molded-case switch has tripped.

C. Overload Relays:

1. Solid-State Overload Relays:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

1) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
2) Analog communication module.

2. NC isolated overload alarm contact.
3. External overload reset push button.

D. Control Power:

1. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 100 VA.

1.9 VARIABLE FREQUENCY CONTROLLERS (VFC)

A. General Requirements for VFCs: Refer to Corning incorporated – Sullivan Park Electrical Standard 26 29 23 ‘Variable-Frequency Motor Controllers’ for requirements.

1.10 FEEDER-TAP UNITS

A. MCCB: Comply with UL 489, with to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
h. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate specified fuses with lockable handle.

C. Fuses are specified in Division 26 Section "Fuses."

1.11 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, plug-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the MCC short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one NO and one NC, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
10. Four-digit, transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

C. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

D. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277, 208Y/120, 600Y/347-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
2. Line to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.
3. Neutral to Ground: 800 V for 480Y/277, 400 V for 208Y/120, 1200 V for 600Y/347.

E. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

1. Line to Neutral: 400 V, 800 V from high leg.
2. Line to Ground: 400 V.
3. Neutral to Ground: 400 V.

F. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

1. Line to Line: 2000 V for 480 V, 1000 V for 240 V, 2500 V for 600 V.
2. Line to Ground: 1500 V for 480 V, 800 V for 240 V, 2500 V for 600 V.

1.12 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. PTs: IEEE C57.13; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bar or window type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground over current relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Listed or recognized by a nationally recognized testing laboratory.
2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
3. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:

   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

d. Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
e. Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

4. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

C. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with MCC watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording 15-minute integrated demand of totalized system.

1.13 MCC CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from CPT.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two CPTs in separate compartments, with interlocking relays, connected to the primary side of each CPT at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

1.14 ENCLOSURES

A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 12 unless otherwise indicated to comply with environmental conditions at installed location.

B. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in MCC.

C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

D. Outdoor Enclosures: Type 3R, with interior-lighted walk-in aisle.

1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
2. Enclosure: Downward, rearward sloping roof; rear hinged doors for each section, with provisions for padlocking.
3. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking.
4. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; GFCI duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
5. Walk-in Aisle Heating and Ventilating:

   a. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 104 deg F (40 deg C).
   b. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 23 deg F (minus 5 deg C).
   c. Ventilating openings complete with replaceable fiberglass air filters.
   d. Thermostat: Single stage; wired to control heat and exhaust fan.

6. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a CPT within the switchboard. Supply voltage shall be 120/208-V ac.
7. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.

E. Compartments: Modular; individual lift-off doors with concealed hinges and quick-captive screw fasteners. Interlocks on units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.

F. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

G. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in bottom and top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

1.15 AUXILIARY DEVICES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oil tight type.

    a. Push Buttons: Recessed types; momentary contact unless otherwise indicated.
    b. Pilot Lights: LED types; push to test.
    c. Selector Switches: Rotary type.

2. Elapsed-Time Meters: Heavy duty with digital readout in hours; non-resettable.
3. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy with selector switches having an off position.

B. Reversible NC/NO contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and under voltage and over voltage relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable under voltage, over voltage, and time-delay settings.

E. Space heaters, with NC auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

G. Cover gaskets for Type 1 enclosures.

H. Terminals for connecting power factor correction capacitors to the line side of overload relays.

I. Spare control-wiring terminal blocks; wired.

J. Spare-Fuse Cabinet: Identified cabinet with hinged lockable door.

1.16 SOURCE QUALITY CONTROL

A. MCC Testing: Inspect and test MCCs according to requirements in NEMA ICS 18.

1.17 INSTALLATION

A. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.

B. Comply with NECA 1.

1.18 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central-control system.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.

1.19 Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors

1.20 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring

1.21 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

END OF SECTION 262419

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Enclosed Bus Assemblies**
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SECTION 262500 - ENCLOSED BUS ASSEMBLIES

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 857.

1.2 PRODUCTS

A. Feeder-Bus Assemblies: Low-impedance bus assemblies in nonventilated housing, single-bolt joints.

1. Electrical Characteristics:

   a. Voltage: Refer to drawings.
   b. Phase: Three; Refer to drawings.
   c. Percent of Neutral Capacity: 100, if neutral is required.

2. Short-Circuit Interrupting Rating:

   a. For Bus Amperage of 800: 85 symmetrical kAIC.
   b. For Bus Amperage of 1200: 100 symmetrical kAIC.
   c. For Bus Amperage of 1600: 125 symmetrical kAIC.
   d. For Bus Amperage of 2500: 150 symmetrical kAIC.
   e. For Bus Amperage of 5000: 200 symmetrical kAIC.

3. Temperature Rise: 55 deg C above 40 deg C ambient.
4. Bus Materials: Copper conductors, fully insulated with Class 130C insulation except at joints.
5. Ground: 50 percent capacity isolated, internal bus bar.
6. Enclosure: Steel, with manufacturer's standard finish. Weatherproof, sealed seams, drains, and removable closures.
7. Fittings and Accessories: Manufacturer's standard.
8. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
9. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs and up to 16 feet (5 m) for vertically mounted runs.

10. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

B. Plug-in Bus Assemblies: Low-impedance bus assemblies in nonventilated housing, single-bolt joints.

1. Electrical Characteristics:

   a. Voltage: Project specific, refer to drawings.
   b. Phase: Three: Project specific, refer to drawings.
   c. Percent of Neutral Capacity: 100%, if neutral is required.

2. Short-Circuit Interrupting Rating:

   a. For Bus Amperage of 800: 85 symmetrical kAIC.
   b. For Bus Amperage of 1200: 100 symmetrical kAIC.
   c. For Bus Amperage of 1600: 125 symmetrical kAIC.
   d. For Bus Amperage of 2500: 150 symmetrical kAIC.
   e. For Bus Amperage of 5000: 200 symmetrical kAIC.

3. Temperature Rise: 55 deg C above 40 deg C ambient.
4. Bus Materials: Copper conductors, fully insulated with Class 130C insulation except at joints.
5. Ground: 50 percent capacity isolated, internal bus bar.
6. Enclosure: Steel, with manufacturer's standard finish.
7. Plug-in Openings: 24 inches (600 mm) o.c. on each side of bus, and hinged covers over unused openings. Plug-in openings shall be finger-safe with covers open or closed.
8. Fittings and Accessories: Manufacturer's standard.
9. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
10. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs and up to 16 feet (5 m) for vertically mounted runs.
11. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

C. Joints:

1. Busway joints shall use one high-strength steel bolt with Belleville washers.
2. Bolts shall be torque indicating type and at ground potential.
3. Bolts shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
4. Access shall be required to only one side of the busway for tightening joint bolts.
5. Joint connection assemblies shall be removable without disturbing adjacent busway lengths.

6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.

D. Plug-in Devices:

1. Fusible Switches: NEMA KS 1, heavy duty; with R-type rejection fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position. See Section 262813 "Fuses" for fuses and fuse installation requirements.

E. Accessories: Hookstick operator, adjustable to maximum extension of 14 feet (4.3 m).

1.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

1.4 INSTALLATION

A. Comply with NECA 1.

1.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.

END OF SECTION 262500

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 262500 - ENCLOSED BUS ASSEMBLIES

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with the following standards:

1. Low Voltage Directive (73/23/EEC) including Amendment (93/68/EEC).
2. Low Voltage Switchgear and Controlgear Assemblies, Part 1: Type Tested and partially type tested Assemblies, IEC 60439-1: 1999.
3. Low Voltage Switchgear and Controlgear Assemblies, Part 2: Particular Requirements for Busbar Trunking systems (Busways), IEC 60439-2: 2000.
4. Underwriters Laboratories Standard, UL 857 – The common UL, CSA, and ANCE Standard for Busways that is derived from the fifth edition of CSA Standard C22.2 No. 27, the twelve edition of UL 857, and the second edition of NMX-J-148-1998-ANCE.
5. Underwriters Laboratories Standard, UL 857 – The common UL, CSA, and ANCE Standard for Busways that is derived from the fifth edition of CSA Standard C22.2 No. 27, the twelve edition of UL 857, and the second edition of NMX-J-148-1998-ANCE.
6. CUL Listing
7. National Electric Code (NEC) – Article 364 – Busways
8. NEMA AB1, Molded Case Circuit Breakers and Molded Case Switches
9. NEMA KS-1, Enclosed and Miscellaneous Distribution Equipment Switches (600VAC).
10. NFPA 70 – National Fire Protection Agency.

1.2 PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Universal Electric Corporation.

1.3 BUSWAY

A. Frame and Enclosure:

1. Extruded Aluminum housing designed to be lightweight and act as a 100% ground. Housings to be 5, 10, or 20 ft standard length. This housing should be properly extruded with slots to receive rod mount hangers to hang from a ceiling. This housing should be open on the bottom to accept plug-in units. This opening shall pass UL's hypothetical finger probe test.

2. All conductors shall be made of copper and sized to handle 100% of its rating continuously with ambient temperatures below 40°C / 104°F. The conductors shall be electrically isolated from the housing.

B. Ratings:

1. B60 Track Busway

a. Voltage: 120/208V.
b. Frequency: 60 Hz.
c. Ampacity: 60A.
d. Neutral Ampacity: 60A.
e. Conductors: Quantity 4 (Phases A, B, C and Neutral).
f. Grounding: Aluminum Casing.

2. B100 Track Busway

a. Voltage: 120/208V.
b. Frequency: 60 Hz.
c. Ampacity: 100A.
d. Neutral Ampacity: 100A.
e. Conductors: Quantity 4 (Phases A, B, C and Neutral).
f. Grounding: Aluminum casing.

C. Plug-in Units

1. Plug-in units shall be polarized to avoid incorrect installation.
2. Plug-in units shall use fuses for branch circuit protection.
3. Plug-in units shall have locking clips or bolt-on tabs to secure units to the busway.
4. Plug-in units that include drop cords shall be manufactured with cord grips and receptacles as specified in the drawings.
5. Outlet plug-in units:

a. Brushed aluminum box with special plug head which inserts into busway continuous slot and turns 90 degrees to make the spring loaded connection.
b. NEMA 5-20 receptacle.
c. Class CC fuse and fuseholder.
d. Universal Model 0B60E22 series.

6. Circuit breaker/drop cord units

a. Full size junction box with hinged lid, plug head, and an externally operated circuit breaker.
b. Circuit breakers shall be molded case type with number of poles and ratings to match drop cord and receptacle rating.
c. SJO drop cord with wire mesh cord grips at both ends of cord. Cord length shall be as indicated on the drawings.
d. NEMA receptacle configuration as indicated on the drawings.

e. Universal Model CB60-WW Series circuit breaker with Model DC60 Series drop cord.

D. Accessories:

1. Power feeds for B60 busway shall be concealed type, Universal EFC60 series. Provide 15 foot wire leads with power feed.
2. End of Runs: End pieces and end caps shall be provided at the end of each run.
3. Closure Strip: A non-metallic closure strip shall be provided for each section of busway where no plug-in devices are installed.

1.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

1.5 INSTALLATION

A. Comply with NECA 1.

1.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.

END OF SECTION 26 25 10

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 262713 - ELECTRICITY METERING

1.1 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Two years.

B. Upgrade Service: Two years.

1.2 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. Meters will be furnished by utility company.

B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

C. Meter Sockets: Comply with requirements of electrical-power utility company.

1.3 ELECTRICITY METERS

1. Comply with UL 1244.
2. Meters used for billing shall have an accuracy of 0.5 percent of reading, complying with requirements in ANSI C12.20.
3. Enclosure: NEMA 250, Type 3R minimum, with hasp for padlocking or sealing.
4. Identification: Comply with requirements in Division 26 Section "Identification for Electrical Systems."
5. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
6. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

    a. Type: Split and solid core.

7. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
8. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

B. Kilowatt-hour Meter: Electronic three-phase meters, measuring electricity used.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.

3. Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.

C. Kilowatt-hour/Demand Meter: Electronic three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand, and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.

D. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section "Control-Voltage Electrical Power Cables."

E. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation and billing.

1. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs.

F. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare tenant bills activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

1.4 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

END OF SECTION 262713

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 262726 - WIRING DEVICES

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.2 PRODUCTS

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1.3 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A.

1.4 USB CHARGER DEVICES

A. Tamper-Resistant, USB Charger Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.

1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
2. USB Receptacles: Dual, Type A.
3. Line Voltage Receptacles: Dual, two pole, three wire, and self-grounding.

1.5 SPD RECEPTACLES

A. General Description: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1449, and FS W-C-596, with integral SPD in line to ground, line to neutral, and neutral to ground.

1. 125 V, 20 A, straight-blade type.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

B. Duplex TVSS Convenience Receptacles

1. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.

C. Isolated-Ground, Duplex Convenience Receptacles

1. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

1.6 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Available Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.

1.7 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

1.8 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.

1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

1.9 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

1.10 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A.

C. Pilot Light Switches, 20 A.

1. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1.11 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

E. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

1.12 FAN SPEED CONTROLS

A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.

1. Continuously adjustable slider, 5 A.

1.13 COMMUNICATIONS OUTLETS

A. Telephone Outlet

1. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet

1. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

1.14 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

1.15 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, flap-type and above-floor, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Blank cover with bushed cable opening.

1.16 POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Service Outlet Assembly: Pedestal type with services indicated.
2. Size: Selected to fit nominal 3-inch (75-mm) cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused 3-inch (75-mm) cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two, 4-pair, Category 5e voice and data communication cables.

1.17 MULTIOUTLET ASSEMBLIES

A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

B. Raceway Material: Metal, with manufacturer's standard finish.

C. Wire: No. 12 AWG.

1.18 SERVICE POLES

A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.

1. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
3. Finishes: Manufacturer's standard painted finish and trim combination.
4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
6. Voice and Data Communication Outlets: Blank insert with bushed cable opening.

1.19 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring Devices Connected to Normal Power System: Ivory, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

1.20 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right

END OF SECTION 262726

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Fuses**
Document Number	**26 28 13**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
Document Owner	**Facilities Electrical Engineering**
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SECTION 262813 - FUSES

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 or 600-V, zero- to 600-A rating, 200 kAIC.
2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, time delay.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
5. Type T: 250-V, zero- to 1200-A; 600-V, zero- to 800-A rating, 200 kAIC, very fast acting.

B. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

C. Applications:

1. Service Entrance: Class L, time delay; Class RK1, time delay.
2. Feeders: Class L, time delay; Class RK1, time delay.
3. Motor Branch Circuits: Class RK1, time delay.
4. Large Motor Branch (601-4000 A): Class L, time delay.
5. Power Electronics Circuits: Class T, fast acting.
6. Other Branch Circuits Class J, time delay.
7. Control Transformer Circuits: Class CC, time delay, control transformer duty.
8. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

1.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuse holders and sockets. Ensure that adapters are irremovable once installed.

END OF SECTION 262813

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Enclosed Switches and Circuit Breakers**
Document Number	**26 28 16**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
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SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1.1 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, over current protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

1.2 FUSIBLE SWITCHES

A. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories (refer to project documents for requirements):

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit (only where required by project documents): Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

9. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

1.3 NONFUSIBLE SWITCHES

A. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit (only where required by project documents): Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

1.4 RECEPTACLE SWITCHES

A. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac, 30, 60 or 100 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

B. Type HD, Heavy-Duty, Single-Throw Non-fusible Switch: 600-V ac, 30, 60 or 100 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

1.5 SHUNT TRIP SWITCHES

A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

B. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

D. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight red ON pilot light.
3. Isolated neutral lug; 200 percent rating.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

1.6 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rams sensing, with the following field-adjustable settings:

1. Instantaneous trip.

2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers (only where noted on project documents): With Class B ground-fault protection (30-mA trip).

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered, remote mounted and powered.

1.7 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; a brand of Schneider Electric.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered.

1.8 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: NEMA 250, Type 12.

B. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

1.9 INSTALLATION

A. Comply with NECA 1.

1.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.

END OF SECTION 262816

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Manual and Magnetic Motor Controllers**
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SECTION 262913.03 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

D. Use of Full-Voltage controllers on motors larger than 10HP requires written approval of S&T/WPS Facilities Engineering.

1.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on

1. Standard: Comply with NEMA ICS 2, general purpose, Class A
2. Configuration: Nonreversing.
3. Surface mounting.
4. Red pilot light.
5. Additional Nameplates: FORWARD and REVERSE for reversing switches; HIGH and LOW for two-speed switches.

1.3 Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action.

1. Configuration: Nonreversing.
2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
3. Surface mounting.
4. Red pilot light.

B. Integral Horsepower Manual Controllers (IHPMC): "Quick-make, quick-break" toggle or push-button action.

1. Configuration: Nonreversing.
2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type.

3. Surface mounting.
4. Red pilot light.
5. N.O. auxiliary contact.

1.4 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across the line start, magnetically held, for system voltage 600-V ac or less.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A

C. Configuration: Non-reversing.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

F. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. CPT Spare Capacity: 100 VA

G. Solid-State Overload Relay:

1. Switch or dial selectable for motor running overload protection.
2. Sensors in each phase.
3. Class 10/20 selectable tripping.
4. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. N.C., isolated overload alarm contact.

I. External overload reset push button.

1.5 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Controller, short circuit and overcurrent protection devices in a single enclosure.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A

C. Configuration: Non-reversing.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

F. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. CPT Spare Capacity: 100 VA.

G. Solid-State Overload Relay:

1. Switch or dial selectable for motor running overload protection.
2. Sensors in each phase.
3. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. N.C., isolated overload alarm contact.

I. External overload reset push button.

J. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

1.6 REDUCED-VOLTAGE MAGNETIC CONTROLLERS

A. Description: Electrically held; closed-transition; adjustable time delay on transition, 600-V ac or less.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A

C. Configuration:

1. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
2. Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.

3. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral over-temperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

F. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. CPT Spare Capacity: 100 VA.

G. Solid-State Overload Relay:
1. Switch or dial selectable for motor running overload protection.
2. Sensors in each phase.
3. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. N.C., isolated overload alarm contact.
1. External overload reset push button.

1.7 COMBINATION REDUCED-VOLTAGE MAGNETIC CONTROLLERS

A. Description: Factory-assembled, combination reduced-voltage magnetic motor controller consisting of the controller described in this article indicated disconnecting means, short circuit and overcurrent protection devices in a single enclosure.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A

C. Configuration:

1. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
2. Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
3. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral over-temperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

F. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

   1. CPT Spare Capacity: 100 VA.

G. Solid-State Overload Relay:
   1. Switch or dial selectable for motor running overload protection.
   2. Sensors in each phase.
   3. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
   4. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. N.C., isolated overload alarm contact.

I. External overload reset push button.

J. Fusible Disconnecting Means:

   1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
      a. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

1.8 MULTISPEED MAGNETIC CONTROLLERS

A. Description: Two speed, full voltage, across the line, electrically held.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration: Nonreversing.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

F. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. CPT Spare Capacity: 100 VA.

G. Compelling relays shall ensure that motor will start only at low speed.

H. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.

I. Decelerating timer relays shall ensure automatically timed deceleration through each speed.

J. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.

K. Solid-State Overload Relay:

1. Switch or dial selectable for motor running overload protection.
2. Sensors in each phase.
3. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator

1.9 COMBINATION MULTISPEED MAGNETIC

A. Description: Factory-assembled, combination of multispeed magnetic motor controller, consisting of the controller, indicated disconnecting means, and short circuit and overcurrent protection devices in a single enclosure.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A

C. Configuration: Nonreversing.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

F. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. CPT Spare Capacity: 100 VA.

G. Compelling relays shall ensure that motor will start only at low speed.

H. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.

I. Decelerating timer relays shall ensure automatically timed deceleration through each speed.

J. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.

K. Solid-State Overload Relay:

1. Switch or dial selectable for motor running overload protection.
2. Sensors in each phase.
3. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    a. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator

L. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

1.10 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: Type 12.
6. Hazardous Areas Indicated on Drawings: Type 7

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

1.11 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

B. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oil tight type.
   1. Push Buttons: Recessed types; momentary as indicated.
   2. Pilot Lights: LED types; colors as indicated; push to test.
   3. Selector Switches: Rotary type.

C. Elapsed Time Meters: Heavy duty with digital readout in hours; non-resettable.

D. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

E. Reversible N.C./N.O. auxiliary contact(s).

F. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

G. Phase-Failure, Phase-Reversal, and under voltage and over voltage relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable under voltage, over voltage, and time-delay settings.

H. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

I. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

J. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

K. Cover gaskets for Type 1 enclosures.

L. Terminals for connecting power factor correction capacitors to the line side of overload relays.

M. Spare control wiring terminal blocks, quantity as indicated; wired.

1.12 INSTALLATION

A. Comply with NECA 1.

1.13 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Testing: Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

END OF SECTION 262913.03

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Soft-Start Motor Controllers**
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1	D. Luchaco	07/19	--	Standards Review	

SECTION 262913.06 – SOFT-START MOTOR CONTROLLERS

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Fabricate and label enclosed controllers to comply with UL 508.

C. NEMA Compliance: Fabricate motor controllers to comply with NEMA ICS 2.

1.2 ENCLOSED SOFT-START MOTOR CONTROLLERS

A. Controllers designed for reduced-voltage start, full-voltage run, and optional soft stop. The controller shall be an integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration: Standard duty.

1. At least two SCRs per phase to control the starting and stopping of the motor.
2. Microprocessor control shall continuously monitor current and proper operation of the SCRs.
3. Bypass Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Soft-start controller protective features and deceleration controls shall remain active when this contactor is in the bypass mode.
4. Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and shall open automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.
5. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
6. Surge Protection: Comply with NEMA ICS 2 requirements for surge suppression.

D. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
2. Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.

E. Controller Diagnostics and Protection:

1. Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics, and providing controller over temperature and motor-overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
3. Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.

F. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:

1. Starter Status: "Ready," "starting," "stopping," or "run."
2. Motor current in amperes.
3. Faults:

   a. Motor overcurrent trip.
   b. Motor thermal overload.
   c. Starter thermal fault.
   d. Low line voltage.
   e. Loss of a phase.
   f. Phases reversed.
   g. Maximum stating time exceeded.
   h. Serial communications error.

G. Interface Panel: Mounted on controller door.

1. Guarded adjustable set points, not readily accessible.

   a. Motor FLA, adjustable from 40 to 110 percent of the controller's rating.
   b. Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
   c. NEMA ICS 2 overload class. Selections shall include the following tripping classes: Class 5, Class 10, Class 15, Class 20, and Class 30.

2. Adjustable set points, readily accessible, password protected.

   a. Linear acceleration, adjustable from 1 to 60 s.
   b. Maximum start time, adjustable from 1 to 250 s.
   c. Selector switch; select coast to stop or soft stop.
   d. Linear deceleration, adjustable from 1 to 60 s.

H. Remote Output Features. All outputs shall be prewired to terminal blocks.

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc; 4- to 20-mA dc.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

1.3 COMBINATION SOFT-START CONTROLLERS

A. Description: Factory-assembled, combination, reduced-voltage soft-start controller with a disconnecting means, short circuit and overcurrent protection devices in a single enclosure. The reduced-voltage soft-start controller shall consist of an integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration: Standard duty.

1. At least two SCRs per phase to control the starting and stopping of the motor.
2. Microprocessor control shall continuously monitor current and proper operation of the SCRs.
3. Bypass Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Soft-start controller protective features and deceleration controls shall remain active when this contactor is in the bypass mode.
4. Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and shall open automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.
5. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
6. Surge Protection: Comply with NEMA ICS 2 requirements for surge suppression.

D. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
2. Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.

E. Controller Diagnostics and Protection:

1. Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics, and providing controller over temperature and motor-overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
3. Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.

F. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:

1. Starter Status: "Ready," "starting," "stopping," or "run."
2. Motor current in amperes.
3. Faults:
    a. Motor overcurrent trip.
    b. Motor thermal overload.
    c. Starter thermal fault.
    d. Low line voltage.
    e. Loss of a phase.
    f. Phases reversed.
    g. Maximum stating time exceeded.
    h. Serial communications error.

G. Interface Panel: Mounted on controller door.

1. Guarded adjustable set points, not readily accessible.
    a. Motor FLA, adjustable from 40 to 110 percent of the controller's rating.
    b. Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
    c. NEMA ICS 2 overload class. Selections shall include the following tripping classes: Class 5, Class 10, Class 15, Class 20, and Class 30.
2. Adjustable set points, readily accessible, password protected.
    a. Linear acceleration, adjustable from 1 to 60 s.
    b. Maximum start time, adjustable from 1 to 250 s.
    c. Selector switch; select coast to stop or soft stop.
    d. Linear deceleration, adjustable from 1 to 60 s.

H. Remote Output Features. All outputs shall be prewired to terminal blocks.

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc; 4- to 20-mA dc.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

I. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

1.4 BYPASS MOTOR CONTROLLER:

A. Description: Factory-assembled, combination, full-voltage electromagnetic motor controller with a disconnecting means, SCPD and OCPD, in a single enclosure. Connected as a bypass controller, operating manually, with NORMAL/BYPASS selector switch

B. Standard:

1. Comply with NEMA ICS 2, general purpose, Class A.
2. Fabricate and label the bypass motor controllers to comply with UL 60947-4-1.

C. Configuration: Across-the-line start, electrically held.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard unless otherwise indicated.

E. Control Power: 120-V ac; obtained from integral CPT, with primary and secondary fuses, and with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. Spare CPT Capacity: As indicated on Drawings, 100 VA.

F. Overload Relays:

1. Solid-State Overload Relays:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

G. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator

1.5 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: Type 12.
6. Hazardous Areas Indicated on Drawings: Type 7

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

1.6 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

B. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oil tight type.
   1. Push Buttons: Recessed types; momentary as indicated.
   2. Pilot Lights: LED types; colors as indicated; push to test.
   3. Selector Switches: Rotary type.

C. Elapsed Time Meters: Heavy duty with digital readout in hours; non-resettable.

D. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

E. Reversible N.C./N.O. auxiliary contact(s).

F. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

G. Phase-Failure, Phase-Reversal, and Under voltage and Over voltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable under voltage, over voltage, and time-delay settings.

H. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

I. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

J. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

K. Cover gaskets for Type 1 enclosures.

L. Terminals for connecting power factor correction capacitors to the line side of overload relays.

M. Spare control wiring terminal blocks, quantity as indicated; wired.

1.7 INSTALLATION

A. Comply with NECA 1.

1.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Testing: Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

END OF SECTION 262913.06

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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1	D. Luchaco	07/19	--	Standards Review	

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. IEEE Compliance: See 2.1.G.11 vibration spec.

D. Manufacturer must have a minimum of 20 years of documented experience, specializing in variable frequency drives.

E. Manufacturer must have published data showing a calculated MTBF (mean time between failures) of at least 25 years.

F. Products must be manufactured by the vendor in a facility owned by the vendor. “Third Party” or “Brand Labeled” products are not acceptable.

G. All products used shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 1 year. This installation shall NOT be used as a test site for any new products unless explicitly approved by Corning in writing prior to bid date. Spare parts shall be available for at least 7 years after completion of this project.

1.2 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

2. Warranty shall include both parts and labor.

3. A Manufacturer’s authorized warranty repair center (MAWRC) shall be located within 2 hours travel time from the Corning, New York location.
   a. The MAWRC shall have a signed contract with the VFC stating the MAWRC is authorized to service products under warranty.
   b. The MAWRC shall have been in business servicing VFC’s no less than 15 years.
   c. The MAWRC shall have a minimum of 3 certified field service technicians on staff at all times.
   d. The MAWRC shall respond to Corning’s request for warranty service within 12 hours

1.3 MANUFACTURED UNITS

A. Applications

1. General Purpose

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1) ABB.
2) Baldor Electric Company.
3) Danfoss Inc.; Danfoss Drives Div.
4) Eaton Electrical Inc.; Cutler-Hammer Business Unit.
5) Emerson Industrial Automation, Control Techniques
6) General Electric Company; GE Consumer & Industrial - Electrical Distribution.
7) Rockwell Automation, Inc.; Allen-Bradley Brand.
8) Siemens Energy & Automation, Inc.
9) Square D; a brand of Schneider Electric.
10) Toshiba International Corporation.
11) Yaskawa Electric America, Inc; Drives Division.
12) TECO

2. HVAC

a. Manufacturers: Subject to compliance with requirements, provide products by the following as defined in S&T/WPS Design Standard Division 230500 Common Work Results for HVAC:

1) Yaskawa Electric America, Inc

3. Process

a. Manufacturers: Subject to compliance with requirements, provide products by the following:

1) Rockwell Automation, Inc.; Allen-Bradley Brand

B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: Variable torque.

D. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, and "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection. The VFC's continuous current rating will meet or exceed the full load amperage rating of the motor to which it is connected.

F. Output Rating: Three-phase; 1 to 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.

G. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.
7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
9. Humidity Rating: Less than 95 percent (non-condensing).
10. Altitude Rating: Not exceeding 3300 feet (1005 m).
11. Vibration Withstand: Comply with IEC 60068-2-6.
12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 1 to 60 Hz.
14. Speed Regulation: Plus or minus 5 percent.
15. See section below regarding Carrier frequency
16. VFC shall include a power loss ride through of 2 seconds.
17. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
18. VFC shall have a motor preheat function to prevent moisture accumulation.
19. VFC shall have a digital operator with program copy and storage function. The operator must be interchangeable for all drive ratings.
20. VFC EMC Rating: Comply with IEC 61800-3:2004 Category C2
21. The VFC must meet the requirements for the Radio Frequency Interference (RFI) above 7MHz as specified by the FCC regulations, part 15, subpart J, Class A devices.

H. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

J. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 50 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Carrier Frequency:

1. VFC shall have an adjustable carrier frequency: The carrier frequency shall have a minimum of 6 settings to allow adjustment in the field.
2. The VFC must be capable of operation at a carrier frequency at or above 5 KHz without derating to satisfy the conditions for current, voltage or horsepower. Exception to this requirement is allowed for VFC’s providing 506 amps or more.

L. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and over voltage trips.
4. Inverter over current trips.
5. VFC and Motor Overload/Over temperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC over temperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable dead bands.
7. Instantaneous line-to-line and line-to-ground over current trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor over temperature fault.

M. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

N. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

O. Bidirectional Auto speed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

P. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

Q. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

R. Integral Input Disconnecting Means and OCPD: NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. NC alarm contact that operates only when circuit breaker has tripped.

S. Equivalent Line Impedance:

1. All VFC's rated between ½ HP to 40HP shall contain a DC link reactor or equivalent AC line reactor.
2. All VFC's rated > 40HP thru 100HP shall contain both a DC link Choke rated at 3% impedance (standard, not an option), and a DC link reactor or equivalent AC line reactor.
3. All VFC's rated between 125HP and greater shall contain an Active Front End (AFE).

1.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Over voltage.
4. Line fault.
5. Over current.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

   a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Elapsed time clock with current time and date. "Real time" is not recommended due to requirement of battery, and associated maintenance.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with elapsed time stamp for each.
5. Fault log to contain fault conditions that occurred during last fault.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

   a. A minimum of two programmable analog inputs: Operator-selectable "x"- to "y"-mA dc.
   b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:

   a. 0- to 10-V dc.
   b. 4- to 20-mA dc.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (operator-selectable "x"- to "y"-mA dc), which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (over temperature or over current).
d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One.

G. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multi-drop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.
2. Embedded BAS Protocols for Network Communications: Echelon LonWorks, Johnson Metasys N2, Modbus/Memobus, Siemens System 600 APOGEE; protocols accessible via the communications ports.

1.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at the point of common coupling (PCC) of all VFCs to less than 5 percent and THD (V) to 3 percent. Reference IEEE 519 1992.

B. Output Filtering: Project Specific.
1. All VFC's that are mounted greater than 150 feet away from the motor must have a Dv/Dt, (LCR type) filter installed within 12 feet of the VFC.
2. All VFC's greater than 100HP shall have a Dv/Dt, (LCR) filter installed within 12 feet of the VFC.

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

1.6 BYPASS SYSTEMS

A. Bypass Requirement: Bypass functionality is required on project specific basis only. Refer to project construction documents

B. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter

C. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, IEC-rated contactor.
2. Input and Output Isolating Contactors: Non-load-break, IEC-rated contactors.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
4. Designs utilizing circuit boards with voltage levels in excess of 120VAC are not acceptable
5. All components shall be mounted on a single plane in the enclosure. For ease of maintenance, designs using components “stacked” or mounted in multiple planes shall not be acceptable.
6. Circuit boards for the control of the bypass operation shall be common among all ratings of the bypass controllers.

D. Bypass Contactor Configuration: Comply with requirements in Division 26 Section "Full-Voltage Controllers."

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

6. Overload Relays: NEMA ICS 2.

   a. Solid-State & Electro-Mechanical Overload Relays:

      1) Switch or dial selectable for motor-running overload protection.
      2) Sensors in each phase.
      3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      5) Analog communication module. Define

   b. NC isolated overload alarm contact.
   c. External overload reset push button.

1.7 STANDARD FEATURES

A. Damper control circuit with end of travel feedback capability.

B. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

C. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

D. Energy Savings Function: Automatically adjusts the volts to hertz ratio for improved energy savings.

E. Security Lock Out Function: Requires (if programmed) a security code to be entered before allowing changes to parameters.

F. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station or smoke-control fan controller, this password-protected input:

   1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
   2. Forces VFC to transfer to Bypass Mode and operate motor at full speed.
   3. Causes display of Override Mode on the VFC display.
   4. Reset VFC to normal operation on removal of override signal manually.

G. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

H. Remote digital operator kit.

I. Communication Port: RS-232 port, USB 2.0 port, RJ-45 port or equivalent connection capable of connecting a notebook computer.

J. Communication software shall be provided standard and free of charge by the VFC manufacturer. Software shall be capable of reading, writing, storing, and printing all programmable parameters. Software shall also be capable of trending, and charting all monitor parameters in real time.

1.8 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and a motor served by it, and generates fault indications, when overload protection activates.

1.9 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

1.10 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

   a. Push Buttons: Recessed types; momentary.
   b. Pilot Lights: LED types; push to test.
   c. Selector Switches: Rotary type.
   d. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Over voltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, over voltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, Type 12; UL 508 component recognized: Supply fan, with stainless steel intake and exhaust grills and filters; 120 -V ac; obtained from integral CPT.

I. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

J. Spare control-wiring terminal blocks; wired.

1.11 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2. Each unit shall be individually tested with a motor under load after final assembly.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
3. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

A. VFCs will be considered defective if they do not pass tests and inspections.

1.12 INSTALLATION

A. All work to comply with the National Electrical Code section 110-26, section 430, section 70E, and section 70B: Life Safety Codes and the New York State Building Codes.

B. Install all VFC’s in accordance with the manufacturer’s written instructions.

C. Install input and output power wiring in separate ferrous based conduit. Aluminum tube and PVC is not accepted.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. When the VFC is located remotely from the motor and the associated disconnect switch, provide an interlock in the disconnect switch and provide 2 #14AWG in 3/4" steel conduit from the VFC to the interlock. This shall be interfaced to disable the VFC prior to disconnection of power to the motor.

I. Comply with NECA 1.

1.13 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1.14 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

1.15 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Factory technical support shall be provided, without additional cost, for the life of the product.

END OF SECTION 262923

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 263323.11 - CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

1.1 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:

a. Central Battery Equipment (excluding Batteries): Two year(s).
b. Standard VRLA Batteries:

1) Full Warranty: One year(s).
2) Pro Rata: Nine years.

c. Premium VRLA Batteries:

1) Full Warranty: One year(s).
2) Pro Rata: 19 years.

d. NiCad, Wet-Cell Batteries:

1) Full Warranty: Five years.
2) Pro Rata: 15 years.

1.2 INTERRUPTIBLE (SLOW-TRANSFER) CENTRAL BATTERY EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Chloride Systems.
2. Controlled Power Company; an Emerson company.
3. Cooper Industries, Inc.
4. Crucial Power Products.
5. Dual-Lite.
6. Emergi-Lite; a Thomas & Betts brand.
7. LightGuard, a Philips Group Brand.
8. Lithonia Lighting; Acuity Brands Lighting, Inc.
9. Thomas & Betts Corporation, a Member of the ABB Group.

B. General Requirements for Interruptible (Slow-Transfer) Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Source Limitations: Obtain central battery equipment, including batteries, overcurrent protective devices, components, and accessories, from single source from single manufacturer.

C. Performance Requirements:

1. Slow-Transfer Central Battery Equipment: Passive-standby (off-line) system. Automatically sense loss of normal alternating-current (ac) supply and use an electromechanical transfer switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.
2. Automatic Operation:

   a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, bypassing inverter, with battery connected in parallel via rectifier/charger output.
   b. Abnormal Supply Conditions: If normal ac supply deviates from specified voltage, transfer switch operates and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
   c. If normal power fails, transfer switch operates and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
   d. If a fault occurs in system when being supplied by inverter and current flows in excess of the overload rating of inverter, inverter automatically protects itself against damage from overloads and short circuits by shutting down.
   e. When normal ac power is restored at input supply terminals of unit, controls automatically retransfer the load back to the normal ac supply, with a momentary loss of power to the load. Rectifier/charger then recharges battery.
   f. If normal power failure is prolonged (more than 90 minutes), integral low-voltage battery protective circuit disconnects battery and prevents battery from damage due to deep discharge.
   g. If battery becomes discharged, and when normal ac supply is again available, rectifier/charger recharges battery. When battery is fully charged, rectifier/charger automatically shifts to float-charge mode.
   h. If battery is disconnected, and normal ac power is available, central battery equipment continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus or minus 3 percent of central battery equipment frequency rating.

3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F (20 deg C) and not exceeding 86 deg F (30 deg C).
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F ((70 deg C).)
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F ((40 deg C).)
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet (1005 m).
12. Off-Line Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

F. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

   a. Normal power available.
   b. Status of system.
   c. Battery charging status.
   d. On battery power.
   e. System fault.
   f. External fault.

2. Remote Signal Interfaces:

   a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

      1) Fault or status indication.
      2) On bypass.
      3) Low battery.

   b. Communications Interface: Factory-installed hardware and software to enable a remote PC to program central battery equipment and monitor and display status and alarms.

      1) Communications Ports: RS-232.
      2) Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications and shall be able to communicate directly via

DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: Project specific, refer to drawings for ratings.

I. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 3 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes.
b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Output Voltage Waveform: Sine wave with maximum 3 percent TDD throughout battery operating-voltage range, for 100 percent linear load.
d. Load Power Factor: 0.5 lead to 0.5 lag.
e. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.

J. Rectifier/Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

K. Batteries:

1. Description: Premium VRLA batteries.

a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

L. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses central battery equipment power circuits (inverter and transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
2. Bypass Overload Capability: 1.5 times the base load current.

M. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: As scheduled on Drawings; manufacturer's standard ratings based on unit output ratings.
2. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

   a. Normally Closed: As scheduled on Drawings; with trip alarm; with time delay.
   b. Normally Open: As scheduled on Drawings; with trip alarm; with time delay.

1.3 INTERRUPTIBLE (FAST-TRANSFER) CENTRAL BATTERY EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Chloride Systems.
2. Controlled Power Company; an Emerson company.
3. Cooper Industries, Inc.
4. Dual-Lite.
5. Emergi-Lite; a Thomas & Betts brand.
6. LightGuard, a Philips Group Brand.
7. Lithonia Lighting; Acuity Brands Lighting, Inc.
8. Siltron Emergency Systems.
9. Thomas & Betts Corporation, a Member of the ABB Group.

B. General Requirements for Interruptible (Fast-Transfer) Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924 and UL 1778.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

C. Performance Requirements:

1. Fast-Transfer Central Battery Equipment: Line-interactive (on-line) system. Automatically sense loss of normal ac supply and use a solid-state static switch to transfer load. Transfer in 2-4 ms or less from normal supply to the battery-inverter supply.
2. Automatic Operation:

    a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, bypassing inverter, with the battery connected in parallel via rectifier/charger output.
    b. Abnormal Supply Conditions: If normal ac supply deviates from specified voltage, transfer switch operates and the battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    c. If normal power fails, transfer switch operates and the battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    d. If a fault occurs in system when being supplied by inverter and current flows in excess of the overload rating of inverter, inverter automatically protects itself against damage from overloads and short circuits by shutting down.
    e. When normal ac power is restored at input supply terminals of unit, controls automatically retransfer the load back to the normal ac supply, with a momentary loss of power to the load. Rectifier/charger then recharges the battery.
    f. If normal power failure is prolonged (more than 90 minutes), integral low-voltage battery protective circuit disconnects the battery and prevents the battery from damage due to deep discharge.
    g. If the battery becomes discharged, and when normal ac supply is again available, the rectifier/charger recharges battery. When the battery is fully charged, the rectifier/charger automatically shifts to float-charge mode.
    h. If the battery is disconnected, and normal ac power is available, the central battery equipment continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus or minus 3 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F (20 deg C) and not exceeding 86 deg F (30 deg C).
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F ((70 deg C).)
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F ((40 deg C).)

10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet (1005 m).
12. Off-Line Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

F. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

    a. Normal power available.
    b. Status of system.
    c. Battery charging status.
    d. On battery power.
    e. System fault.
    f. External fault.

2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

    a. Keypad: In addition to required programming and control keys, include the following:

        1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
        2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
        3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

    b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:

        1) Real-time clock with current time and date.
        2) Tests and Events Logs: Record and store up to 50 tests and events.

            a) Dates.
            b) Times.
            c) Durations.
            d) Output voltage and currents.

        3) Alarm Logs: Record and store up to 50 alarms.

            a) Dates.
            b) Times.

c) Alarm type.

4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:

a) Input and output voltage (V ac) and output current (A ac).
b) Battery voltage (V dc) and current (A ac).
c) Fault or alarming status (code).
d) Power output (VA).
e) Inverter load (W).
f) Ambient temperature (deg F).
g) System run time (cumulative days).
h) Inverter run time (cumulative minutes).

5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:

a) High/low battery charge voltage.
b) High/low input voltage.
c) Battery nearing low-voltage condition.
d) Battery low voltage.
e) High ambient temperature.
f) Inverter fault.
g) Output fault.
h) Output overload.

3. Remote Signal Interfaces:

a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

1) Fault or status indication.
2) On bypass.
3) Low battery.

b. Communications Interface: Factory-installed hardware and software to enable a remote PC to program central battery equipment and monitor and display status and alarms.

1) Communications Ports: RS-232.
2) Network Communications Ports: Ethernet.
3) Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: Project specific, refer to drawings for rating.

I. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 3 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes.
b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Output Voltage Waveform: Sine wave with maximum 3 percent TDD throughout battery operating-voltage range, for 100 percent linear load.
d. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.
e. Load Power Factor: 0.5 lead to 0.5 lag.
f. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.

J. Rectifier/Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

K. Batteries:

1. Description: Premium VRLA batteries.

a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

L. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses central battery equipment power circuits (inverter and static transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
2. Maintenance Bypass Mode: External; manual operation only; bypasses central battery equipment completely; requires local operator selection at external switch enclosure remote from central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
3. Bypass Overload Capability: 1.5 times the base load current.

M. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: As scheduled on Drawings; manufacturer's standard ratings based on unit output ratings.
2. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

   a. Normally Closed: As scheduled on Drawings; with trip alarm; with time delay.
   b. Normally Open: As scheduled on Drawings; with trip alarm; with time delay.

1.4 UNINTERRUPTIBLE (UPS-TYPE) CENTRAL BATTERY EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Chloride Systems.
2. Controlled Power Company; an Emerson company.
3. Cooper Industries, Inc.
4. Dual-Lite.
5. Emergi-Lite; a Thomas & Betts brand.
6. LightGuard, a Philips Group Brand.
7. Lithonia Lighting; Acuity Brands Lighting, Inc.
8. Siltron Emergency Systems.
9. Thomas & Betts Corporation, a Member of the ABB Group.

B. General Requirements for Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924 and UL 1778.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

C. Performance Requirements for UPS-Type Central Battery Equipment:

1. Type: On-line, double conversion.

2. Continuously provide uninterrupted ac power to connected emergency electrical lighting system.
3. Automatic Operation:

   a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier and inverter, with battery connected in parallel with rectifier output.
   b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
   c. If normal power fails, battery continues to supply regulated ac power through the inverter to the load without switching or disturbance.
   d. When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier then supplies power to the load through the inverter and simultaneously recharges battery.
   e. If battery becomes discharged and normal supply is available, rectifier charges battery. When battery is fully charged, rectifier automatically shifts to float-charge mode.
   f. If any element in the rectifier/inverter string fails and power is available at normal supply terminals of system, static transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
   g. If a fault occurs in system supplied by the inverter output, and current flows in excess of the overload rating of the inverter, static transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
   h. When fault has cleared, static transfer switch returns the load to inverter output.
   i. If battery is disconnected, inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

4. Manual Operation:

   a. Turning inverter off causes static transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.
   b. Turning inverter on causes static transfer switch to transfer the load to inverter.

5. Maximum Acoustical Noise: 58 dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches (990 mm) from nearest surface of component enclosure.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus or minus 3 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F (20 deg C) and not exceeding 86 deg F (30 deg C).
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F ((70 deg C).)
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F ((40 deg C).)
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet (1005 m).
12. Off-Line Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

F. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

   a. Normal power available.
   b. Status of system.
   c. Battery charging status.
   d. On battery power.
   e. System fault.
   f. External fault.

2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

   a. Keypad: In addition to required programming and control keys, include the following:

      1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
      2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
      3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

   b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:

      1) Real-time clock with current time and date.
      2) Tests and Events Logs: Record and store up to 50 tests and events:

a) Dates.
b) Times.
c) Durations.
d) Output voltage and currents.

3) Alarm Logs: Record and store up to 50 alarms:

a) Dates.
b) Times.
c) Alarm type.

4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:

a) Input and output voltage (V ac) and output current (A ac).
b) Battery voltage (V dc) and current (A ac).
c) Fault or alarming status (code).
d) Power output (VA).
e) Inverter load (W).
f) Ambient temperature (deg F).
g) System run time (cumulative days).
h) Inverter run time (cumulative minutes).

5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:

a) High/low battery charge voltage.
b) High/low input voltage.
c) Battery nearing low-voltage condition.
d) Battery low voltage.
e) High ambient temperature.
f) Inverter fault.
g) Output fault.
h) Output overload.

3. Remote Signal Interfaces:

a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

1) Fault or status indication.
2) On bypass.
3) Low battery.

b. Communications Interface: Factory-installed hardware and software to enable a remote PC to monitor and display status and alarms and to program central battery equipment.

1) Communications Ports: RS-232.
2) Network Communications Ports: Ethernet.
3) Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: Project specific, refer to drawings for ratings.

I. Rectifier:

1. Description: Solid state, with the following operational features:

a. Automatically convert incoming ac voltage to regulated dc bus voltage, with less than 2 percent rms ripple voltage with inverter fully loaded and batteries disconnected.
b. Rectified Efficiency: Not less than 97 percent.
c. Generator compatible.

J. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 3 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes, with recovery within 3 cycles.
b. Automatically regulate output frequency to within plus or minus 0.05 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.
d. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.
e. Load Power Factor: 0.5 lead to 0.5 lag.

K. Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

L. Batteries:

1. Description: Premium VRLA batteries.

    a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

M. Line Conditioning and Filtering:

1. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at input terminals of indicated central battery equipment to less than 5 percent and THD (V) to 3 percent.
2. Output Voltage Waveform: Sine wave with maximum 3 percent TDD throughout battery operating-voltage range, for 100 percent linear load.

N. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses central battery equipment power circuits (inverter and static transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
2. Maintenance Bypass Mode: External; manual operation only; bypasses central battery equipment completely; requires local operator selection at external switch enclosure remote from central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
3. Bypass Overload Capability: 1.5 times the base load current.

O. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: As scheduled on Drawings; manufacturer's standard ratings based on unit output ratings.
2. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

    a. Normally Closed: As scheduled on Drawings; with trip alarm; with time delay.
    b. Normally Open: As scheduled on Drawings; with trip alarm; with time delay.

1.5 ENCLOSURES

A. Central Battery Equipment Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

1.6 OPTIONAL AND ACCESSORY FEATURES

A. Factory-Installed Options and Accessories:

1. Multiple-Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.
2. Split-Output Configuration: Divides output into normally on and normally off buses.
3. Auto-dialer.
4. Internal fax modem.
5. Audible alarm with silencer switch.
6. Remote Summary Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions; silencing switch in face of panel silences signal without altering visual indication.

   a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
   b. Maximum Distance from Main Unit: 1000 feet (304 m).

7. Remote Meter Panel: Match equipment requirements of remote monitoring, controlling, and programming of central battery equipment.

   a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
   b. Maximum Distance from Main Unit: 150 feet (46 m).

1.7 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate central battery equipment fabricator's quality-control and testing methods.

B. Testing: Test and inspect central battery equipment according to UL 924 and UL 1778.

C. Factory Tests: Test and inspect assembled central battery equipment, by a qualified testing agency, according to UL 924 and UL 1778. Affix standards organization's label. Include the following:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.

2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

D. Central battery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

1.8 INSTALLATION

A. Install central battery equipment and accessories according to NECA 411.

1.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

END OF SECTION 263323.11

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Static Uninterruptible Power Supply**
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1	D. Luchaco	07/19	--	Standards Review	

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

1.1 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Listed and labeled under UL 1778 by an NRTL.

C. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

1.2 WARRANTY

A. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

2. Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	40 cycles
30 minutes	30 minutes	1.67	125 cycles
15 minutes	1.5 minutes	1.67	750 cycles

3. Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.75	40 cycles
1 hour	1 hour	1.75	80 cycles

15 minutes	45 seconds	1.67	2700 cycles

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: Three years from date of Substantial Completion.

1.3 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Double Conversion, IGBT:

    a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
    b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.

2. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.
3. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
4. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
5. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
6. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
7. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
8. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).
2. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
3. Relative Humidity: 0 to 95 percent, non-condensing.
4. Altitude: Sea level to 4000 feet (1220 m).

1.4 PERFORMANCE REQUIREMENTS

A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is 100 percent unbalanced continuously.

B. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is 15 minutes.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 30 percent from nominal voltage.

D. Overall UPS Efficiency: Equal to or greater than 85 percent at 100 percent load, 85 percent at 75 percent load, and 85 percent at 50 percent load.

E. Maximum Acoustical Noise: 58 dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 36 inches from nearest surface of component enclosure.

F. Maximum Energizing Inrush Current: Six times the full-load current.

G. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

H. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

I. Limitation of harmonic distortion of input current to the UPS shall be as follows:

  1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.

J. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

K. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.

L. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:

  1. 50 Percent: Plus or minus 5 percent.
  2. 100 Percent: Plus or minus 5 percent.
  3. Loss of AC Input Power: Plus or minus 1 percent.
  4. Restoration of AC Input Power: Plus or minus 1 percent.

M. Input Power Factor: A minimum of 0.85 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.

N. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging shall not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:

1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.

O. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

1.5 UPS SYSTEMS

A. Manufacturers: Subject to compliance with requirements,:

1. Eaton Corporation; Powerware Division.
2. Mitsubishi Electric Automation, Inc.

B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

C. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

D. Configuration: Field-assembled, multi-cabinet modular style units

E. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

F. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

G. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

H. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

I. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

1.6 SURGE SUPPRESION

A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input

assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

1.7 RECTIFIER-CHARGER

A. Description: Voltage source converter, six-pulse IGBT rectifier

B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

F. NiCad Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging shall be terminated when the rate of temperature rise reaches 1.8 deg F (1 deg C) per minute. If the battery reaches 140 deg F (60 deg C) prior to reaching this rate of temperature rise, charging shall terminate. Chargers that determine full charge by voltage measurement to sense a 10-mV drop per cell when reaching full charge are also acceptable.

1.8 INVERTER

A. Description: Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

1.9 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LCD or LED.

1. Quantitative indications shall include the following:

    a. Input voltage, each phase, line to line.
    b. Input current, each phase, line to line.
    c. Bypass input voltage, each phase, line to line.
    d. Bypass input frequency.
    e. System output voltage, each phase, line to line.
    f. System output current, each phase.
    g. System output frequency.
    h. DC bus voltage.
    i. Battery current and direction (charge/discharge).
    j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:

    a. Normal operation.
    b. Load-on bypass.
    c. Load-on battery.
    d. Inverter off.
    e. Alarm condition.

3. Alarm indications shall include the following:

    a. Bypass ac input overvoltage or undervoltage.
    b. Bypass ac input over frequency or under frequency.
    c. Bypass ac input and inverter out of synchronization.
    d. Bypass ac input wrong-phase rotation.
    e. Bypass ac input single-phase condition.
    f. Bypass ac input filter fuse blown.
    g. Internal frequency standard in use.
    h. Battery system alarm.
    i. Control power failure.
    j. Fan failure.
    k. UPS overload.
    l. Battery-charging control faulty.
    m. Input overvoltage or undervoltage.
    n. Input transformer over temperature.
    o. Input circuit breaker tripped.
    p. Input wrong-phase rotation.
    q. Input single-phase condition.
    r. Approaching end of battery operation.
    s. Battery undervoltage shutdown.
    t. Maximum battery voltage.
    u. Inverter fuse blown.
    v. Inverter transformer over temperature.
    w. Inverter over temperature.
    x. Static bypass transfer switch over temperature.
    y. Inverter power supply fault.
    z. Inverter transistors out of saturation.

aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

1.10 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

C. Input SPD: 80 kA

1.11 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full UPS load current.

D. Mounting Provisions: Separate wall- or floor-mounted unit.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

1.12 OUTPUT DISTRIBUTION

A. Panelboards: Comply with Division 26 Section "Panelboards" except provide assembly integral to UPS cabinet.

1.13 OUTPUT ISOLATION TRANSFORMER

A. Description: Shielded unit with low forward transfer impedance up to 3 kHz, minimum. Include the following features:

1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 9.
2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
3. Regulation: 5 percent, maximum, at rated nonlinear load current.
4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
5. Electrostatic Shielding of Windings: Independent for each winding.
6. Coil Leads: Physically arranged for minimum inter-lead capacitance.
7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
8. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHz.

1.14 REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

1.15 REMOTE MONITORING

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units or modems for data transmission via RS-232 link.

2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Division 26 Section "Electrical Power Monitoring and Control."

1.16 BATTERY

A. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. C&D Technologies, Inc.; Standby Power Division.
2. Eaton Corporation; Powerware Division.
3. EnerSys.

1.17 BASIC BATTERY MONITORING

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Albercorp.
2. BTECH, Inc.
3. Eaton Corporation; Powerware Division.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

C. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

D. Annunciation of Alarms: At UPS control panel.

1.18 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.

2. Connections for data transmission via RS-232 link, network interface and external signal wiring to computer electrical power monitoring and control equipment. External signal wiring and computer are not specified in this Section.
3. PC-based software designed to store and analyze battery data. Software compiles reports on individual-cell parameters and total battery performance trends, and provides data for scheduling and prioritizing battery maintenance.

B. Performance: Automatically measures and electronically records the following parameters on a routine schedule and during battery discharge events. During discharge events, records measurements timed to nearest second; includes measurements of the following parameters:

1. Total battery voltage and ambient temperature.
2. Individual-cell voltage, impedance, and temperature. During battery-discharging events such as utility outages, measures battery and cell voltages timed to nearest second.

1.19 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
2. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
4. Alarm Contacts: Arranged to initiate local and remote alarm for abnormal battery voltage or temperature.
5. Memory: Stores recorded data in nonvolatile electronic memory.
6. RS-232 Port: Permits downloading of data to a portable PC.
7. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

1.20 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation. Include the following:

1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.

2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

1.21 INSTALLATION

A. Comply with NECA 1.

1.22 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

1.23 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.

1.24 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Lightning Protection for Structures**
Document Number	**26 41 13**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 08/2008**
Document Owner	**Facilities Electrical Engineering**
Approvals	**Document Owner, Documentation Administrator**
Key Words	**Identification, Warning tape, Warning labels, Miscellaneous**

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1	D. Luchaco	07/19	--	Standards Review	

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

1.1 SUMMARY

A. Provide a functional and unobtrusive lightning protection system in accordance with the provisions of the latest "Code for Protection against Lightning" for buildings as adopted by the National Fire Protection Association and the Underwriters Laboratories, Inc. for a Master Label System.

B. This is a performance standard. The lightning protection system shall be designed and installed by a Lightning Protection Contractor who specializes in this field.

C. The following specifications and standard of the latest issue form a part of this standard:

1. Lightning Protection Institute Installation Code LPI-175
2. National Fire Protection Association Code No. 780 (2000 edition)

1.2 QUALITY ASSURANCE

A. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.

B. System Completion Certificate:

1. UL Master Label.
2. LPI System Certificate.
3. UL Master Label Recertification.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.3 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. East Coast Lightning Equipment Inc.
2. ERICO International Corporation.
3. Harger Lightning & Grounding.
4. Heary Bros. Lightning Protection Co. Inc.
5. Independent Protection Co.
6. Preferred Lightning Protection.
7. Robbins Lightning, Inc.
8. Thompson Lightning Protection, Inc

1.4 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I or Class II buildings refer to drawings for classification.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I or Class II buildings refer to drawings for classification.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

1.5 COMPONENTS

A. Air Terminals:

1. Aluminum unless otherwise indicated.
2. 1/2-inch (12.7-mm) by 24 inches (610 mm) long.
3. Rounded tip.
4. Threaded base support.

B. Air Terminal Bracing:

1. Aluminum.
2. 1/4-inch (6-mm) diameter rod.

C. Class 1 Main Conductors:

1. Aluminum: 98,600 circular mils in diameter.

D. Class II Main Conductors:

1. Aluminum: 192,000 circular mils in diameter.

E. Secondary Conductors:
1. Aluminum: 41,400 circular mils in diameter.

F. Ground Loop Conductor: Stranded copper**.**

G. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 3/4 inch (19 mm).
3. Rods shall be not less than 120 inches (3050 mm) long.

H. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

1.6 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A and NFPA 780.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

E. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

F. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.

G. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure or area or item indicated.

1. Bury ground ring not less than 24 inches (600 mm) from building foundation.
2. Bond ground terminals to the ground loop.
3. Bond grounded building systems to the ground loop conductor within 12 feet (3.6 m) of grade level.

H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot (18-m) intervals.

1.7 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld or high-compression fittings.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

1.8 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

1.9 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.
2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Surge Protection for Low-Voltage Electrical Power Circuits**
Document Number	**26 43 13**
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1	D. Luchaco	07/19	--	Standards Review	

SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

1.1 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.2 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

1.3 SERVICE ENTRANCE SUPPRESSOR

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ABB USA.
2. AC Data Solutions.
3. Advanced Protection Technologies Inc. (APT).
4. Atlantic Scientific.
5. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
6. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
7. Intermatic, Inc.
8. Leviton Mfg. Company Inc.
9. Liebert Corporation; a division of Emerson Network Power.
10. Northern Technologies, Inc.; a division of Emerson Network Power.
11. Siemens Energy & Automation, Inc.
12. Square D; a brand of Schneider Electric.

B. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

1. SPDs with the following features and accessories:

a. Integral disconnect switch.

b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.
d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
e. Surge counter.

D. Comply with UL 1283.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V; 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V; 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V; 1000 V for 208Y/120 V.

G. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Line to Line: 1000 V.

H. SCCR: Equal or exceed 100 kA.

I. I nominal Rating: 20 kA.

1.4 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ABB USA.
2. AC Data Solutions.
3. Advanced Protection Technologies Inc. (APT).
4. Atlantic Scientific.
5. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
6. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
7. Intermatic, Inc.
8. Leviton Mfg. Company Inc.
9. Liebert Corporation; a division of Emerson Network Power.
10. Northern Technologies, Inc.; a division of Emerson Network Power.

11. Siemens Energy & Automation, Inc.
12. Square D; a brand of Schneider Electric.

B. Surge Suppression Incorporated

C. SPDs: Comply with UL 1449, Type 1.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Comply with UL 1283.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V; 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V; 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277 V; 700 V for 208Y/120 V.
4. Line to Line: 2000 V for 480Y/277 V; 1200 V for 208Y/120 V

G. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

H. SCCR: Equal or exceed 100 kA.

I. I nominal Rating: 20 kA.

1.5 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

1.6 INSTALLATION

A. Comply with NECA 1.

1.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

END OF SECTION 264313

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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2	Dean Luchaco	8/14/13	Cut Sheets	Added new fixtures	
3			Fixture chart/cut sheets	Revised fixture chart / removed cutsheets / renamed – renumbered standard	
4		2/1/2017	Overall	Contacts, incentives, standards	
5		12/2017	Title Page	Revised to BSD Standard	
6		12/2017	1.1.C	Update Horizon Contact List	
7				Revise document format	
8	D. Luchaco	07/19	--	Standard Review	

PART 1 - GENERAL

1.1 SCOPE

A. To assist in the design of lighting for new construction, expansions, or existing facility spaces. Energy management considerations are based on luminaire efficiency, facility energy reduction goals, facility luminaire standardization, and capturing rebate/incentive money.

B. Corning Project Managers will contact WPS Division Energy Manager on all WPS lighting retrofit/upgrade projects.

C. All fixtures and controls installed must be new. Used or rebuilt equipment is not eligible, except for qualifying retrofit kits.

D. Facility Luminaire Standardization for Lighting Systems and Controls foster many benefits such as reduction in stocked materials, and consistency of lighting color, lumen output, and fixture aesthetics from area to area.

1. Interior CCT (correlated color temperature) is standardized at 4000K for all areas. Exceptions have been made for conference rooms and restrooms at 3500K.

2. Exterior CCT is standardized from 5000K to 5700K for all fixtures, including bollards, signs, and spot lights.

3. Exterior controls shall consist of an astronomical time clock circuit, building photo-eye circuit, or individual fixture photo-eyes. Additionally, ML (multi-level) sensors may be used for additional occupancy dimming.

END OF SECTION 26 50 00.01

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities

Document Title	**Light Fixture Chart**
Document Number	**26 50 00.02**
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Original Author and Date	**Dean Luchaco 7/30/15**
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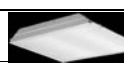
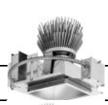
1	Dean Luchaco	7/6/16		Updated chart with latest fixtures	
2	Dean Luchaco	2/14/17		Updated chart with latest fixtures	
3	Dean Luchaco	5/25/17		Updated chart with latest fixtures	
4	D. Luchaco	07/19	--	Standards Review	

CORNING MSA (Electrical Lighting) STANDARD MATERIAL LIST 2018 **Q3: Jul 1, 2018 - Sep 30, 2018**

Assumption: 120 or 277 voltage. Request 480v where necessary (vvv = needs voltage specified 120v or 277v).
INTERIOR - fixtures are standardiazed on 4K CCT (exception for Conference rooms that may be 3.5K CCT)
EXTERIOR - fixtures are standardized on 5K CCT
EMERGENCY LIGHTING - Self testing diagnostic exits, combo exits, and "bug-eyes" are preferred standard. Emergency BB in fixture to be considered as last resort.
NOTES:
System Owner Approval is required if not utilizing the Corning MSA Standards. Alan Fritschy <FritschyAJ@corning.com> is the Corning Point of Contact for all MSA edits/approvals.
Part numbers represent common fixtures. These need to be verified prior to quotes and ordering (watts, lumens, CCT, distribution, lens, voltage, etc.).
Planning must take into account desired Performance Color (CCT) specfic to each facility based on Corning Standards.
Product lead times are based upon standard availability after receipt of order by Horizon Solution.
Lead times will vary based upon quantity. Please call Horizon Solutions for most current/accurate lead times.
Horizon Solutions - Energy Division is available to consult on design, drawings, standardization, and incentive administration - 585-274-8233.

INTERIOR - new fixtures are standardiazed on 4K CCT (Verify: specific to facility, integral sensor, mounting type/height)

CORNING CODE	PICTURE	DESCRIPTION	MANUF	CATALOG NUMBER	NOTES
NLED 2x2 ARC SC		2X2 RECESSED LED TROFFER W/INTEGREL SMARTCAST SENSOR*	CREE	ZR22T-32L-40K-CMA-FL	100,000 hrs, 10yr wnty.
NLED 2x4 ARC SC		2X2 RECESSED LED TROFFER W/INTEGREL SMARTCAST SENSOR*	CREE	ZR24T-40L-40K-CMA-FL	100,000 hrs, 10yr wnty.
NLED 1x4 ARC SC		2X2 RECESSED LED TROFFER W/INTEGREL SMARTCAST SENSOR*	CREE	ZR14T-40L-40K-CMA-FL	100,000 hrs, 10yr wnty.
NLED 2x2 ARC		1X4 RECESSED LED TROFFER	CREE	ZR22T-32L-40K-10V	100,000 hrs, 10yr wnty.
NLED 2x4 ARC		1X4 RECESSED LED TROFFER	CREE	ZR24T-40L-40K-10V	100,000 hrs, 10yr wnty.
NLED 1x4 ARC		1X4 RECESSED LED TROFFER	CREE	ZR14T-40L-40K-10V	100,000 hrs, 10yr wnty.
NLED 2x2 FP		2X2 LED FLAT PANEL	CREE	C-TR-A-FP22-40L-40K-WH	79,500 hrs, 5yr wnty.
NLED 2x4 FP		2X4 LED FLAT PANEL	CREE	C-TR-A-FP24-50L-40K-WH	79,500 hrs, 5yr wnty.
NLED 1x4 FP		1X4 LED FLAT PANEL	CREE	C-TR-A-FP14-40L-40K-WH	79,500 hrs, 5yr wnty.
NLED 2x2 AH		2X2 RECESSED LED TROFFER - AIR HANDLING	ESI	F-22LX-L2VN-40-FR-AH-D	150,000 hrs, 5yr(ext to 10yr) wnty.
NLED 2x4 AH		2X4 RECESSED LED TROFFER - AIR HANDLING	ESI	F-24LX-L4N-40-FR-AH-D	150,000 hrs, 5yr(ext to 10yr) wnty.
NLED 1x4 AH		1X4 RECESSED LED TROFFER - AIR HANDLING	ESI	F-14LX-L4N-40-FR-AH-D	150,000 hrs, 5yr(ext to 10yr) wnty.
NLED 2x2		2X2 STANDARD RECESSED TROFFER	LITHONIA	2GTL-2-33L-SWL-EZ1-LP840	100,000 hrs, 5yr wnty.
NLED 2x4		2X4 STANDARD RECESSED TROFFER	LITHONIA	2GTL-4-48L-SWL-EZ1-LP840	100,000 hrs, 5yr wnty.
NLED 1x4		1X4 STANDARD RECESSED TROFFER	LITHONIA	GTL-4-33L-SWL-EZ1-LP840	100,000 hrs, 5yr wnty.
NLED 2x2 CR		2X2 LED - CLEANROOM, CLASS 100	KENALL	CSEDI-22-45L40K-DCC-DV-2F-2H-SYM	80,000 hrs, 5yr wnty.
NLED 2x4 CR		2X4 LED - CLEANROOM, CLASS 100	KENALL	CSEDI-24-67L40K-DCC-DV-2F-2H-SYM	80,000 hrs, 5yr wnty.
NLED 2x4 CRG		2X4 LED - GASKETED, NO CLASS RATING	LITHONIA	2GTL4 72L SWL EZ1 LP840 ABC	60,000 hrs, 5yr wnty.
NLED HB-IS		HIGHBAY LED - >16' - INTERGAL SENSOR	FLEXTRONICS	ES40P-A1-31K-4M-40-80+-FR-LV-CRM-10V-OCCDIM40	238,000 hrs, 5yr(10yr avail.) wnty.
NLED LB-IS		LOWBAY LED - <16' - INTERGAL SENSOR	FLEXTRONICS	ES40P-A1-15K-4MS-40-80+-FR-LV-CRM-10V-OCCDIM20	238,000 hrs, 5yr(10yr avail.) wnty.
NLED HB		HIGHBAY LED - >16'	LITHONIA	IBG 30000LM HEF AFL GND MVOLT OZ10 40K 80CRI DWH	100,000 hrs, 5yr wnty.
NLED LB		LOWBAY LED - <16'	LITHONIA	IBG 15000LM HEF AFL GND MVOLT OZ10 40K 80CRI DWH	100,000 hrs, 5yr wnty.
NLED S4		STRIP - 4' LED	LITHONIA	ZL1N-L48-SMR-5000LM-FST-MVOLT-40K-80CRI-WH	100,000 hrs, 5yr wnty.
NLED S8		STRIP -8' LED	LITHONIA	TZL1N-L96-SMR-10000LM-FST-MVOLT-40K-80CRI-WH	100,000 hrs, 5yr wnty.
NLED STR		1X4 LED STAIRWELL DIMMING	LITHONIA	WL4 30L EZ1 LP840 N100 NES7 DIM10	60,000 hrs, 5yr wnty.
NLED VT		VAPORTIGHT 4' LED	LITHONIA	FEM-L48-6000LM-LPAFL-MD-MVOLT-GZ10-40K-80CRI	100,000 hrs, 5yr wnty.
NLED VTH		VAPORTIGHT 4', LED, HIGH LUMEN	LITHONIA	FEM-L48-10000LM-LPAFL-MD-MVOLT-GZ10-40K-80CRI	100,000 hrs, 5yr wnty.
NLED VN2		VANITY 2', SQUARE LED	LITHONIA	FMVTSL-24IN-MVOLT-40K-90CRI-BN	50,000 hrs, 5yr wnty.
NLED VN4		VANITY 4', SQUARE LED	LITHONIA	FMVTSL-48IN-MVOLT-40K-90CRI-BN	50,000 hrs, 5yr wnty.
NLED DL4R		RECESSED 4" LED DOWNLIGHT ROUND	LITHONIA	LDN4 40/15-LO4-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL4S		RECESSED 4" LED DOWNLIGHT SQUARE	LITHONIA	LDN4SQ 40/15-LO4-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL6R		RECESSED 6" LED DOWNLIGHT ROUND	LITHONIA	LDN6 40/20-LO6-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL6S		RECESSED 6" LED DOWNLIGHT SQUARE	LITHONIA	LDN6SQ 40/20-LO6-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL8R		RECESSED 8" LED DOWNLIGHT ROUND	LITHONIA	LDN8 40/60-LO8-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL8S		RECESSED 8" LED DOWNLIGHT SQUARE	LITHONIA	LDN6SQ 40/60-LO8-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL4R		RECESSED 4-5" LED DOWNLIGHT ROUND RETROFIT	LITHONIA	LDN4RV-40/20-LR-4-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED DL8R		RECESSED 6" LED DOWNLIGHT ROUND RETROFIT	LITHONIA	LDN6RV-40/40-LR-6-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
RLED DL6R		RECESSED 8" LED DOWNLIGHT ROUND RETROFIT	LITHONIA	LDN8RV-40/80-LR-8-WR-LSS-MVOLT-GZ1	50,000 hrs, 5yr wnty.
NLED 1x1 BA		RECESSED 12" LED ARCH SQUARE	FINELITE	HPR-LED-A-1X1-DCO-S-840-vvv-D-DW	200,000 hrs, 10yr wnty.
NLED EC		EXIT COMBO (discontinued)	DUAL LITE	EVC-U-R-W-D-I	Self-Diagnostic (SP Standard)
NLED EM		EMERGENCY FIXTURE ("BUG-EYE")	LITHONIA	ELM2-LED-SD	Self-Diagnostic (SP Standard)
NLED E		EXIT	LITHONIA	LHQM-LED-R-HO-SD	Self-Diagnostic W/ Remote EM Heads
NLED EC		EXIT COMBO	LITHONIA	LHQM-LED-R-HO RO-SD	Self-Diagnostic

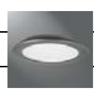
CORNING MSA (Electrical Lighting) STANDARD MATERIAL LIST 2018 **Q3: Jul 1, 2018 - Sep 30, 2018**

Assumption: 120 or 277 voltage. Request 480v where necessary (vvv = needs voltage specified 120v or 277v).
INTERIOR - fixtures are standardiazed on 4K CCT (exception for Conference rooms that may be 3.5K CCT)
EXTERIOR - fixtures are standardized on 5K CCT
EMERGENCY LIGHTING - Self testing diagnostic exits, combo exits, and "bug-eyes" are preferred standard. Emergency BB in fixture to be considered as last resort.
NOTES:
System Owner Approval is required if not utilizing the Corning MSA Standards. Alan Fritschy <FritschyAJ@corning.com> is the Corning Point of Contact for all MSA edits/approvals.
Part numbers represent common fixtures. These need to be verified prior to quotes and ordering (watts, lumens, CCT, distribution, lens, voltage, etc.).
Planning must take into account desired Performance Color (CCT) specfic to each facility based on Corning Standards.
Product lead times are based upon standard availability after receipt of order by Horizon Solution.
Lead times will vary based upon quantity. Please call Horizon Solutions for most current/accurate lead times.
Horizon Solutions - Energy Division is available to consult on design, drawings, standardization, and incentive administration - 585-274-8233.

INTERIOR - Retrofit Lamps for Existing Fixtures (DIR = Plug and Play, Ballast Compatible Only), (RLRD = LED Lamps w/LED Driver Installed)

CORNING CODE	PICTURE	DESCRIPTION	MANUF	CATALOG NUMBER	NOTES
RLED T8 4'		4' T8/LED LAMP BC/DRIVE	SYLVANIA	LED13T8/L48/DIM/841/SUB/G8 75510	50,000 hrs, 5yr wnty.
RLED T8 3'		3' T8/LED LAMP BC/DRIVE	SYLVANIA	LED12T8/L36/FG/841/SUB/G6 75130	50,000 hrs, 5yr wnty.
RLED T8 2'		2' T8/LED LAMP BC/DRIVE	SYLVANIA	LED8T8/L24/FG/841/SUB/G7	50,000 hrs, 5yr wnty.
RLED T8 U		4' UBEND T8/LED LAMP (HYB)	SYLVANIA	LED15T8/U/FP/841/SUB/G6	50,000 hrs, 5yr wnty.
RLRD T8 1L		1L RELAMP/DRIVER (2'; 3'; 4')	SYLVANIA	QHE1XLEDT8/UNV ISN-SC 75311	80,000 hrs. 5yr wnty
RLRD T8 2L		2L RELAMP/DRIVER (2'; 3'; 4')	SYLVANIA	QHE2XLEDT8/UNV ISN-SC 75312	80,000 hrs. 5yr wnty
RLRD T8 3L		3L RELAMP/DRIVER (2'; 3'; 4')	SYLVANIA	QHE3XLEDT8/UNV ISN-SC 75313	80,000 hrs. 5yr wnty
RLRD T8 4L		4L RELAMP/DRIVER (2'; 3'; 4')	SYLVANIA	QHE4XLEDT8/UNV ISN-SC 75314	80,000 hrs. 5yr wnty
RLED T5 22"		2' T5/LED LAMP (DIR), w/ ballast only	SYLVANIA	LED7T5HE/L24/FG/841/SUB 40090	50,000 hrs, 5yr wnty.
RLED T5 33'		3' T5/LED LAMP (DIR), w/ ballast only	SYLVANIA	LED10T5HE/L36/FG/841/SUB 40094	50,000 hrs, 5yr wnty.
RLED T5 44"		4' T5/LED LAMP (DIR), w/ ballast only	SYLVANIA	LED13T5HE/L48/FG/841/SUB 40109	50,000 hrs, 5yr wnty.
RLED T5 HO 44"		4' T5HO/LED LAMP (DIR), w/ ballast only	SYLVANIA	LED25T5HO/L48/FG/841/SUB/G6 79748	50,000 hrs, 5yr wnty.

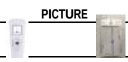
EXTERIOR - fixtures are standardiazed on 5K CCT (Verify: Distribution type, PE/ML sensor, Color, Mounting)

CORNING CODE	PICTURE	DESCRIPTION	MANUF	CATALOG NUMBER	NOTES
NLED B		BOLLARD (NEW)	KIM	VRB1 20L 5K UV	100,000 hrs, 5yr wnty.
NLED BA		BOLLARD (NEW) ALTERNATE	HYDREL	3110C-H42-8COB-50K-MVOLT-SYM-BZ	100,000 hrs, 5yr wnty.
RLED B		BOLLARD (RETRO-LED KIT)	KIM	VRB-LED-KIT 20L 5K UV	100,000 hrs, 5yr wnty.
NLED W70		WALL PACK - 70W EQUAL	CREE	SEC-EDG-3M -WM-02-E-UL-350	100,000 hrs, 10yr wnty.
NLED W100		WALL PACK - 100W EQUAL	CREE	SEC-EDG-3M -WM-02-E-UL-525	100,000 hrs, 10yr wnty.
NLED W150		WALL PACK - 150W EQUAL	CREE	SEC-EDG-3M -WM-02-E-UL-700	100,000 hrs, 10yr wnty.
NLED W250		WALL PACK - 250W EQUAL	CREE	SEC-EDG-3M -WM-04-E-UL-700	100,000 hrs, 10yr wnty.
NLED W400		WALL PACK - 400W EQUAL	CREE	SEC-EDG-3M -WM-06-E-UL-700	100,000 hrs, 10yr wnty.
NLED A175		AREA ARM MOUNT -175W EQUAL	CREE	ARE-EDG-3M-DA-04-E-UL-525	100,000 hrs, 10yr wnty.
NLED A250		AREA ARM MOUNT -250W EQUAL	CREE	ARE-EDG-3M-DA-04-E-UL-700	100,000 hrs, 10yr wnty.
NLED A400		AREA ARM MOUNT -400W EQUAL	CREE	ARE-EDG-3M-DA-06-E-UL-700	100,000 hrs, 10yr wnty.
NLED A800		AREA ARM MOUNT -800W EQUAL	CREE	ARE-EDG-3M-DA-16-E-UL-525	100,000 hrs, 10yr wnty.
NLED A1000		AREA ARM MOUNT -1000W EQUAL	CREE	OSQ-A-NM-XXX-S-40K-UL	100,000 hrs, 10yr wnty.
NLED C150		CANOPY SURFACE MNT - 150 EQUAL	EATON	TT-C4-LED-E1-xx-xxx-xx-7050	250,000 hrs. 5yr wnty.
NLED C250		CANOPY SURFACE MNT - 250 EQUAL	EATON	TT-C6-LED-E1-xx-xxx-xx-7050	250,000 hrs. 5yr wnty.
NLED AF250		ADJUSTABLE FLOOD - 250W EQUAL	CREE	FLD-EDG-40-AA-02-E-UL-700	100,000 hrs, 10yr wnty.
NLED AF400		ADJUSTABLE FLOOD - 400W EQUAL	CREE	FLD-EDG-40-AA-06-E-UL-700	100,000 hrs, 10yr wnty.
NLED AF800		ADJUSTABLE FLOOD - 800W EQUAL	CREE	FLD-EHO-40-AA-12-E-UH-700	100,000 hrs, 10yr wnty.
NLED SF150		SPOT FLOOD - 150W EQUAL	CREE	FLD-EDG-SN-SA-02-E-UL-700	100,000 hrs, 10yr wnty.
NLED SF250		SPOT FLOOD - 250W EQUAL	CREE	FLD-EDG-SN-SA-04-E-UL-700	100,000 hrs, 10yr wnty.
NLED SF400		SPOT FLOOD - 400W EQUAL	CREE	FLD-EDG-SN-SA-06-E-UL-700	100,000 hrs, 10yr wnty.
NLED SH400		STREET HEADS - 400W EQUAL	CREE	STR-LWYL3M-HT-08-E-UL-xx-525	100,000 hrs, 10yr wnty.
NLED SH1000		STREET HEADS - 1000W EQUAL	CREE	STR-LWYL3M-HT-11-E-UL-xx-700	100,000 hrs, 10yr wnty.

SENSORS

CORNING CODE	PICTURE	DESCRIPTION	MANUF	CATALOG NUMBER	NOTES
CLED CS W		CEILING SENSOR (WIRELESS)	LUTRON	LRF2-OCR2B-P-WH	Relay Pack for Zone Control
CLED HS W		HALLWAY SENSOR (WIRELESS)	LUTRON	LRF2-OHLB-P-WH	Relay Pack for Zone Control
CLED WSD W		WALL SWITCH DIMMER (WIRELESS)	LUTRON	PJ2-3BRL-G-WH/PICO-WBX-ADPT	Relay Pack for Zone Control
CLED PP W		POWER PACK (FOR WIRELESS)	LUTRON	RMJS-8T-DV-B	Relay Pack for Zone Control
CLED WSD 1G		WALL SWITCH DIMMER (1-GANG)	LUTRON	NTSTV-DV-WH	0-10v, use in single gang box
CLED WSD MG		WALL SWITCH DIMMER (MULTI-GANG)	LUTRON	DVSTV-WH	0-10v, use in multi gang box
CLED WSD OCC		WALL SWITCH DIMMER WITH OCCUPANCY	LUTRON	MS-Z101-WH	0-10v
CLED WSD LV		WALL SWITCH DIMMER (LINE VOLTAGE)	LUTRON	DVCL-253P-WH	120v
CLED CS DT AUX		CEILING SENSOR, DUAL TECH, AUX CONTACTS, & PP	LUTRON	LOS-CDT-1000R-PP-DV	for HVAC status
CLED CS DT AUX A		CEILING SENSOR, DUAL TECH, AUX CONTACTS, & PP (Alternate)	SENSOR SWITCH	CMR-PDT-10-PP20	for HVAC status
CLED PC		PANEL CONTROLLER, 6-ZONE	LUTRON	QSGRJ-6P	Grafik-Eye
CLED PC ECO		PANEL CONTROLLER, 6-ZONE, W/ ECOSYSTEM	LUTRON	QSGRJ-6E	Grafik-Eye with Ecosystem

ACCESSORIES*

CORNING CODE	PICTURE	DESCRIPTION	MANUF	CATALOG NUMBER	NOTES
WWD SC		Smart Cast wireless dimming wall sensor	CREE	CWD-CWC-WH	for smartcast fixtures
PT SC		Smart Cast Programming tool	CREE	CCT-CWC-1	for smartcast fixtures

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**LED Interior Lighting**
Document Number	**26 51 19**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 12/2017**
Document Owner	**Facilities Electrical Engineering**
Approvals	**Document Owner, Documentation Administrator**
Key Words	**Identification, Warning tape, Warning labels, Miscellaneous**

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2	CISP

Rev #	Revision Originator	Revision Date	Sections Revised	Summary of Revisions made	
1	D. Luchaco	07/19	--	Standards Review	

SECTION 265119 - LED INTERIOR LIGHTING

1.1 RELATED DOCUMENTS

A. Reference S&T/WPS Standard 26 50 00.01 ‘Lighting Standard’ for additional light fixture requirements.

B. Reference S&T/WPS Standard 26 51 13 Light Fixture Chart and Cut Sheets for permissible manufacturers and models.

1.2 WARRANTY

A. Materials and Workmanship for Luminaires: Five years.

1.3 ENERGY EFFICIENCY STANDARDS

A. In order for products to qualify for utility based incentives, they must qualify under the standards of ENERGY STAR® or the DesignLights™ Consortium (DLC).

B. For Solid State Lighting (SSL) products (i.e. LEDs) other protocols may allow these products to qualify, such as LM79 and LM80 test results, coupled with an unconditional five (5) year warranty on product (from either manufacturer or installer).

1.4 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

C. Recessed Fixtures: Comply with NEMA LE 4.

D. Bulb shape complying with ANSI C79.1.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. CRI of minimum 80, CCT of 4100 K.

G. Rated lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 1 percent of maximum light output.

I. Internal driver.

J. Nominal Operating Voltage: 120 Vac. and 277 Vac.

K. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

L. Luminaire Types: Refer to project documents for requirements.

M. Factory-applied labels: Labels shall include the following lamp characteristics:

1. "USE ONLY" and include specific lamp type.
2. Lamp diameter, shape, size, wattage, and coating.
3. CCT and CRI for all luminaires.

N. Luminaire Support:

1. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
2. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
3. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
4. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

1.5 INSTALLATION

A. Comply with NECA 1.

1.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

END OF SECTION 265119

Electrical Performance Standard

This Document Defines or Describes Construction DesignStandards
For Use At S&T/WPS Facilities.

Document Title	**Emergency and Exit Lighting**
Document Number	**26 52 13**
Document Type	**Electrical Performance Standard**
Original Author and Date	**Dean Luchaco 12/2017**
Document Owner	**Facilities Electrical Engineering**
Approvals	**Document Owner, Documentation Administrator**
Key Words	**Identification, Warning tape, Warning labels, Miscellaneous**

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Rev #	Revision Originator	Revision Date	Sections Revised	Summary of Revisions made	
1	D. Luchaco	07/19	--	Standards Review	

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

1.1 RELATED DOCUMENTS

A. Reference S&T/WPS Standard 26 50 00.01 ‘Lighting Standard’ for additional light fixture requirements.

B. Reference S&T/WPS Standard 26 51 13 Light Fixture Chart and Cut Sheets for permissible manufacturers and models.

1.2 WARRANTY

A. Materials and Workmanship for Luminaires and Emergency Lighting Batteries: Two years.

1.3 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

1.4 EMERGENCY LIGHTING

A. System Description: Self-contained emergency lighting assemblies.

1. Emergency Luminaires:

   a. Internal or External emergency power unit.
   b. Operating at nominal voltage of 120 V ac or 277 V ac.
   c. Rated for installation in damp locations and for sealed and gasketed fixtures in wet locations.
   d. UL 94 5VA flame rating.

2. Emergency Lighting Unit:

   a. Operating at nominal voltage of 120 V ac or 277 V ac.
   b. Wall with universal junction box adaptor.
   c. UV stable thermoplastic housing, rated for damp locations.
   d. Two LED lamp heads.
   e. Internal or External emergency power unit.

3. Remote Emergency Lighting Unit:

   a. Operating at nominal voltage of 120 V ac, 277 V ac, 6 V dc, 9.6 V dc, 12 V dc, or 24 V dc.
   b. Wall with universal junction box adaptor.
   c. UV stable thermoplastic housing, rated for damp locations.
   d. Two LED lamp heads.
   e. Emergency connection.
   f. Automatically operating relay.
   g. Test push-button and indicator light.
   h. Automatic, integral self-test electronic device.

1.5 EXIT SIGNS

A. System Description: Exit Signs.

1. Internally Lighted Signs:

   a. Operating at nominal voltage of 120 V ac or 277 V ac.
   b. Lamps for AC Operation: Fluorescent, two for each fixture; 20,000 hours of rated lamp life.
   c. Self-powered exit signs with internal emergency power unit.

2. Self-Luminous Signs:

   a. Tritium powered.
   b. Strontium oxide aluminate compound for ambient-light storage.

1.6 INSTALLATION

A. Comply with NECA 1.

1.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

END OF SECTION 265219

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

Document Title	**Lighting Poles and Standards**
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1	D. Luchaco	07/19	--	Standards Review	

SECTION 265613 - LIGHTING POLES AND STANDARDS

1.1 WARRANTY

A. Materials and Workmanship for Poles: 5 years.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Structural Characteristics: Comply with AASHTO LTS-6-M.

C. Live Load: Single load of 500 lbf (2200 N).

D. Ice Load: Load of 3 lbf/sq. ft. (145 Pa).

E. Wind Load: According to AASHTO LTS-6-M.

1. Basic wind speed for poles exceeding 50 feet (15 m) is 100 mph (45 m/s).

   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 50 years.
   c. Velocity Conversion Factor: 1.0.

2. Basic wind speed for poles 50 feet (15 m) high or less is 100 mph (45 m/s).

   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 25 years.
   c. Velocity Conversion Factor: 1.0.

F. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

G. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated

1.3 PRODUCTS

A. Poles: Refer to project documents for requirements.

B. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

C. Grounding: Bare, stranded copper, #6 AWG, suspended inside of pole, connected to luminaire(s), ground lug near handhole and ground rod.

D. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

1.4 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

1.5 POLE FOUNDATION

A. Refer to project documents for requirements.

1.6 INSTALLATION

A. Comply with NECA 1.

B. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

C. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches (1520 mm).
2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet (3 m).
3. Trees: 15 feet (5 m) from tree trunk.

D. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer.

1.7 FIELD QUALITY CONTROL

A. Inspect poles for nicks, mars, dents, scratches, and other damage.

END OF SECTION 265613

Electrical Performance Standard

This Document Defines or Describes Construction Design Standards For Use At S&T/WPS Facilities.

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SECTION 265619 - LED EXTERIOR LIGHTING

1.1 RELATED DOCUMENTS

A. Reference S&T/WPS Standard 26 50 00.01 ‘Lighting Standard’ for additional light fixture requirements.

B. Reference S&T/WPS Standard 26 51 13 Light Fixture Chart and Cut Sheets for permissible manufacturers and models.

1.2 WARRANTY

A. Materials and Workmanship for Luminaires: Two years.

1.3 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. CRI of minimum 70. CCT of 4100 K.

H. L70 lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 120 V ac, 277 V ac or 480V ac.

L. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

M. Source Limitations: Obtain luminaires from single source from a single manufacturer.

1.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

1.5 LUMINAIRE TYPES

A. Refer to drawings and schedules

1.6 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

C. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

E. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

F. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage and coating.
   c. CCT and CRI for all luminaires.

1.7 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, matches finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

   a. Color: Confirmed with owner.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

   a. Color: As selected from manufacturer's standard catalog of colors.

1.8 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

1.9 INSTALLATION

A. Comply with NECA 1.

1.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

END OF SECTION 265619