



# Construction Specification Manual

## Salt River Project

### Technical Specification Index – April 2022

#### Division 26

Division	Title	Updated
<b>DIVISION 26: ELECTRICAL</b>		
<b>260500</b>	Common Work Results for Electrical	New 04/22
<b>260519</b>	Low Voltage Conductors and Cables	Revised 04/22
<b>260523</b>	Control Voltage Electrical Power Cables	Revised 04/22
<b>260526</b>	Grounding and Bonding	Revised 04/22
<b>260529</b>	Hangers and Supports	Revised 04/22
<b>260533</b>	Raceways and Boxes	Revised 04/22
<b>260536</b>	Cable Trays for Electrical Systems	Revised 04/22
<b>260544</b>	Sleeves and Sleeve Seals for Electrical Raceways and Cabling	Revised 04/22
<b>260553</b>	Identification for Electrical Systems	Revised 04/22
<b>260800</b>	Commissioning Of Electrical Systems	New 06/22
<b>260913</b>	Electrical Power Monitoring	Revised 04/22
<b>260923</b>	Lighting Control Devices	Revised 04/22
<b>262200</b>	Low Voltage Transformers	Revised 04/22
<b>262413</b>	Switchboards	Revised 04/22
<b>262416</b>	Panelboards	Revised 04/22
<b>262419</b>	Motor Control Centers	Revised 04/22
<b>262600</b>	Power Distribution Units	New 04/22
<b>262713</b>	Electricity Metering	New 04/22
<b>262726</b>	Wiring Devices	Revised 04/22
<b>262813</b>	Fuses	Revised 04/22
<b>262816</b>	Enclosed Switches and Circuit Breakers	Revised 04/22
<b>262913</b>	Enclosed Controllers	Revised 04/22
<b>263231</b>	Engine Generators	Revised 04/22
<b>263235</b>	Standby Generator Testing & Commissioning	Revised 04/22
<b>233353</b>	Static Uninterruptible Power Supply (UPS)	Revised 04/22
<b>263354</b>	Static UPS Testing and Commissioning	Revised 04/22
<b>263355</b>	Static UPS (Large System) Testing and Commissioning	Revised 04/22
<b>263600</b>	Transfer Switches	Revised 04/22
<b>264113</b>	Lightning Protection for Structures	New 04/22
<b>264313</b>	Transient Voltage Suppression	Revised 04/22
<b>265100</b>	Interior Lighting	Revised 04/22
<b>265600</b>	Exterior Lighting	Revised 04/22

## SECTION 26 05 00

### COMMON WORK RESULTS FOR ELECTRICAL

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes:
  - 1. Sleeves for raceways and cables.
  - 2. Sleeve seals.
  - 3. Grout.
  - 4. Common electrical installation requirements.

##### 1.2 SUBMITTALS

- A. Product Data: For sleeve seals.

#### PART 2 - PRODUCTS

##### 2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

##### 2.2 SLEEVE SEALS

- 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. Advance Products & Systems, Inc.
  - 2. Calpico, Inc.
  - 3. Metraflex Co.
  - 4. Pipeline Seal and Insulator, Inc.
  - 5. 3M, Inc.
- B. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

## 2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

## PART 3 - EXECUTION

### 3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

### 3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
  - 1. Cut sleeves to length for mounting flush with both surfaces of walls.
  - 2. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
  - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
  - 4. Seal space outside of sleeves with grout for penetrations of concrete and masonry
  - 5. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

- D. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section 07 92 00 "Joint Sealants".
- E. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section 07 84 13 "Penetration Firestopping."
- F. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- G. 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.

### 3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
  - 1. Use 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.

### 3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section 07 84 13 "Penetration Firestopping."

**END OF SECTION**

## SECTION 26 05 19

### LOW VOLTAGE CONDUCTORS AND CABLES

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes:
  - 1. Building wires and cables rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

#### PART 2 - PRODUCTS

##### 2.1 CONDUCTORS AND CABLES

- A. Copper Conductors: Comply with NEMA WC 70.
- B. Conductor Insulation: Types THW, THHN-THWN, XHHW, UF, USE, and SO.
- C. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC metal-clad cable, Type MI nonmetallic-sheathed cable, Type NM Type SO and Type USE with ground wire.
- D. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

##### 2.2 SYSTEM DESCRIPTION

- 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.

## PART 3 - EXECUTION

### 3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders, Copper: Install stranded conductors unless otherwise indicated.
- B. Branch Circuits, Copper: Install stranded conductors unless otherwise indicated. No solid conductors are allowed unless specifically approved by Owner.

### 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway Type XHHW, single conductors in raceway. Type SE or USE multiconductor cable
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway. For fished installations only, Armored cable, Type AC Metal-clad cable.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway Underground feeder cable, Type UF.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway. Only when approved in writing by Owner: Armored cable: Type AC, Metal-clad cable: Type MC.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway. Only with written approval by owner on an application-by-application basis armored cable, Type AC or metal-clad cable, Type MC.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway. Underground branch-circuit cable: Type UF.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- J. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes. Power-limited tray cable, in cable tray.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

- B. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
    - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. Test Reports: Prepare a written report to record the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

**END OF SECTION**

## SECTION 26 05 23

### CONTROL VOLTAGE ELECTRICAL POWER CABLES

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Sections Included:
1. Multimode optical-fiber cabling.
  2. UTP cabling.
  3. RS-485 cabling.
  4. Low-voltage control cabling.
  5. Control-circuit conductors.
  6. Identification products.

##### 1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Source quality-control reports.
- C. Field quality-control reports.

#### PART 2 - PRODUCTS

##### 2.1 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.

##### 2.2 PERFORMANCE REQUIREMENTS

- A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
1. Flame Travel Distance: 60 inches (1520 mm) or less.
  2. Peak Optical Smoke Density: 0.5 or less.
  3. Average Optical Smoke Density: 0.15 or less.
- B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.



- C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

## 2.3 BACKBOARDS

- A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Section 06 10 53 "Miscellaneous Rough Carpentry."
- B. Painting: Paint plywood on sides and edges with flat black latex paint. Comply with requirements in Section 09 91 23 "Interior Painting."

## 2.4 OPTICAL- FIBER CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  1. Belden Inc.
  2. CommScope, Inc.
  3. Corning Incorporated.
  4. Emerson Connectivity Solutions.
  5. General Cable Technologies Corporation.
  6. Mohawk; a division of Belden Inc.
  7. Nexans; Berk-Tek Products.
  8. Siemon Company (The).
  9. Superior Essex Inc.
  10. SYSTIMAX Solutions; a CommScope, Inc. brand.
  11. 3M.
  12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
- C. Description: Multimode, 50/125-micrometer, 24-fiber, nonconductive, tight-buffer, optical-fiber cable.
  1. Comply with ICEA S-83-596 for mechanical properties.
  2. Comply with TIA-568-C.3 for performance specifications.
  3. Comply with TIA-492AAAB-A for detailed specifications.
  4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    - a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    - b. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
    - c. Plenum Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.

- d. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
  - e. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.
  - f. Riser Rated, Nonconductive: Type OFNR or Type OFNP in listed riser or plenum communications raceway.
  - g. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
  - h. General Purpose, Nonconductive: Type OFN, Type OFNG, Type OFNG, or Type OFNP.
  - i. General Purpose, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in listed communications raceway.
  - j. General Purpose, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
  - k. Plenum Rated, Conductive: Type OFCP complying with NFPA 262.
  - l. Plenum Rated, Conductive: Type OFCP in listed plenum communications raceway.
  - m. Plenum Rated, Conductive: Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
  - n. Riser Rated, Conductive: Type OFCR or Type OFCP; complying with UL 1666 and ICEA S-103-701.
  - o. Riser Rated, Conductive: Type OFCR or Type OFCP in listed riser or plenum communications raceway.
  - p. Riser Rated, Conductive: Type OFC, Type OFCG, Type OFCP, or Type OFCR in metallic conduit.
  - q. General Purpose, Conductive: Type OFC or Type OFCG, Type OFCR, or Type OFCP.
  - r. General Purpose, Conductive: Type OFC, Type OFCG, Type OFCP, or Type OFCR in listed communications raceway.
  - s. General Purpose, Conductive: Type OFC, Type OFCG, Type OFCP, or OFCR in metallic conduit.
- 5. Conductive cable shall be aluminum-armored type.
  - 6. Maximum Attenuation: 3.25 dB/km at 850 nm; 1.2 dB/km at 1300 nm.
  - 7. Minimum Modal Bandwidth: 500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

D. Jacket:

- 1. Jacket Color: Aqua for 62.5/125-micrometer cable.
- 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
- 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

## 2.5 OPTICAL- FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. ADC.
  - 2. American Technology Systems Industries, Inc.
  - 3. Belden Inc.
  - 4. Corning Incorporated.
  - 5. Dynacom Inc.
  - 6. Hubbell Incorporated.
  - 7. Molex Premise Networks; a division of Molex, Inc.
  - 8. Panduit Corp.
  - 9. Siemon Company (The).
  
- C. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
  - 1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
  
- D. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
  
- E. Cable Connecting Hardware:
  - 1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA-568-C.3.
  - 2. Quick-connect, simplex and duplex, Type LC connectors. Insertion loss of not more than 0.5 dB.
  - 3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

## 2.6 UTP CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. ADC.
  - 2. Alpha Wire Company; a division of Belden Inc.
  - 3. Belden Inc.
  - 4. CommScope, Inc.
  - 5. Draka Cableteq USA.
  - 6. Genesis Cable Products; Honeywell International, Inc.
  - 7. Mohawk; a division of Belden Inc.
  - 8. Nexans; Berk-Tek Products.
  - 9. Siemon Company (The).

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10. Superior Essex Inc.
11. SYSTIMAX Solutions; a CommScope, Inc. brand.
12. 3M.
13. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

C. Description: 100-ohm, four-pair UTP

1. Comply with ICEA S-90-661 for mechanical properties of Category 5e cables.
2. Comply with ICEA S-102-700 for mechanical properties of Category 6 cables.
3. Comply with TIA-568-C.1 for performance specifications.
4. Comply with TIA-568-C.2, Category 5e, Category 6.
5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with NEMA WC 66, UL 444, and NFPA 70 for the following types:
  - a. Communications, Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway.
  - b. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
  - c. Communications, Riser Rated: Type CMR complying with UL 1666 and ICEA S-103-701.
  - d. Communications, Riser Rated: Type CMP, or Type CMR in listed plenum or riser communications raceway.
  - e. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
  - f. Communications, General Purpose: Type CM, Type CMG, Type CMP, or Type CMR in listed communications raceways.
  - g. Communications, General Purpose: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
  - h. Communications, Limited Purpose: Type CMX or Type CM, Type CMG, Type CMP, or Type CMR.

## 2.7 UTP CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  1. ADC.
  2. American Technology Systems Industries, Inc.
  3. Belden Inc.
  4. Dynacom Inc.
  5. Hubbell Incorporated.
  6. Leviton Commercial Networks Division.
  7. Molex Premise Networks; a division of Molex, Inc.
  8. Panduit Corp.

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9. Siemon Company (The).
  10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
- C. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- D. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.
- F. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
1. Number of Jacks per Field: One for each four-pair UTP cable indicated.
- G. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.
- H. Patch Cords: Factory-made, four-pair cables in 60-inch (1500-mm) lengths; terminated with eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
  2. Patch cords shall have color-coded boots for circuit identification.
- I. Workstation Outlets: Four-port-connector assemblies mounted in single faceplate.
- J. Faceplates:
1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 26 27 26 "Wiring Devices."
  2. Metal Faceplate: Stainless steel complying with requirements in Section 26 27 26 "Wiring Devices."
  3. For use with snap-in jacks accommodating combination of UTP, optical-fiber, and coaxial work area cords.
    - a. Flush-mounted jacks, positioning the cord at a 45-degree angle.
- K. Legend:
1. Factory labeled by silk-screening or engraving for stainless steel faceplates.
  2. Machine printed, in the field, using adhesive-tape label.
  3. Snap-in, clear-label covers and machine-printed paper inserts.

## 2.8 TWIN- AXIAL DATA HIGHWAY CABLE

- A. Plenum-Rated Cable: NFPA 70, Type CMP.
  - 1. Paired, 1 pair, No. 20AWG, stranded (7x28) tinned-copper conductors.
  - 2. Plastic insulation.
  - 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
  - 4. Plastic jacket.
  - 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x28) tinned-copper drain wire.
  - 6. Flame Resistance: Comply with NFPA 262.

## 2.9 RS-485 CABLE

- A. Plenum-Rated Cable: NFPA 70, Type CMP.
  - 1. Paired, two pairs, No. 24 AWG, stranded (7x32) tinned-copper conductors.
  - 2. Fluorinated ethylene propylene insulation.
  - 3. Unshielded.
  - 4. Fluorinated ethylene propylene jacket.
  - 5. Flame Resistance: NFPA 262.

## 2.10 LOW-VOLTAGE CONTROL CABLE

- A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
  - 1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
  - 2. PVC insulation.
  - 3. Unshielded.
  - 4. PVC jacket.
  - 5. Flame Resistance: Comply with NFPA 262.

## 2.11 CONTROL- CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway; power-limited cable, concealed in building finishes; power-limited tray cable, in cable tray; complying with UL 83.
- D. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.
  - 1. Smoke control signaling and control circuits.

## 2.12 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP cables according to TIA-568-C.2.
- C. Factory test optical-fiber cables according to TIA-568-C.3.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Test cables on receipt at Project site.
  - 1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
  - 2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
  - 3. Test each pair of UTP cable for open and short circuits.

### 3.2 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
  - 1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
  - 2. Outlet boxes for optical-fiber cables shall be no smaller than 4 inches (102 mm) square by 2-1/8 inches (53 mm) deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
  - 3. Flexible metal conduit shall not be used.
- B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
- C. Install manufactured conduit sweeps and long-radius elbows if possible.
- D. Raceway Installation in Equipment Rooms:
  - 1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
  - 2. Install cable trays to route cables if conduits cannot be located in these positions.
  - 3. Secure conduits to backboard if entering the room from overhead.

4. Extend conduits 6 inches (150 mm) above finished floor.
  5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- E. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1 and NFPA 70.
- B. General Requirements for Cabling:
1. Comply with TIA-568-C Series of standards.
  2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
  3. Terminate conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
  4. Cables may not be spliced.
  5. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
  7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
  8. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Do not use heat lamps for heating.
  9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
  10. Support: Do not allow cables to lay on removable ceiling tiles.
  11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
- C. UTP Cable Installation:
1. Comply with TIA-568-C.2.
  2. Install termination hardware as specified in Section 27 15 13 "Communications Copper Horizontal Cabling" and Section 27 15 23 "Communications Optical Fiber Horizontal Cabling" unless otherwise indicated.
  3. Do not untwist UTP cables more than 1/2 inch (12 mm) at the point of termination to maintain cable geometry.
- D. Installation of Control-Circuit Conductors:

#### CONTROL VOLTAGE ELECTRICAL POWER CABLES

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1. Install wiring in raceways. Comply with requirements specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

E. Optical-Fiber Cable Installation:

1. Comply with TIA-568-C.3.
2. Terminate cable on connecting hardware that is rack or cabinet mounted.

F. 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 30 inches (760 mm) apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 72 inches (1830 mm) of cable in a coil not less than 12 inches (305 mm) in diameter.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.

### 3.4 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

### 3.5 CONTROL- CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No. 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No. 12 AWG.

### 3.6 FIRESTOPPING

- A. Comply with requirements in Section 07 84 13 "Penetration Firestopping."
- B. Comply with TIA-569-B, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

## CONTROL VOLTAGE ELECTRICAL POWER CABLES

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### 3.7 GROUNDING

- A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

### 3.8 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

### 3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Visually inspect UTP and optical-fiber 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 components.
  - 3. Test UTP 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 "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
  - 4. Optical-Fiber Cable Tests:
    - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    - b. Link End-to-End Attenuation Tests:
      - 1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      - 2) Attenuation test results for links shall be less than that calculated according to equation in TIA-568-C.0.
- B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

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- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

**END OF SECTION**

## SECTION 26 05 26

### GROUNDING AND BONDING

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes:
  - 1. Methods and materials for grounding systems and equipment.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

##### 1.4 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 UL 467 for grounding and bonding materials and equipment.

#### PART 2 - PRODUCTS

##### 2.1 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
  - 1. Solid Conductors: ASTM B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Tinned Conductors: ASTM B 33.
  - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

## 2.2 CONNECTORS

- A. 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.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
  1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

## 2.3 GROUNDING ELECTRODE SYSTEM

- A. Ground Rods: Copper-clad or Zinc-coated in diameter and length as indicated for all generator installations and new buildings.
- B. Ground Ring: For all generator installations and new buildings, encircle each with a copper conductor of a size as indicated
- C. Concrete Encased Electrode (Ufer): For all generator installations and new buildings connect the slab reinforcing steel to the grounding electrode conductor with a permanent bond.
- D. Structural Steel: for all new buildings connect the structural steel to the concrete encased electrode and the grounding electrode conductor as indicated
- E. Metal underground water pipe: for all new buildings, connect to the grounding electrode conductor if indicated.

## 2.4 GROUNDING ELECTRODE CONDUCTORS

- A. Install stranded (unless otherwise indicated) copper conductors of the size required by the drawings.

# PART 3 - EXECUTION

## 3.1 APPLICATIONS

- A. Conductors: Install stranded conductor, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, 2/0 AWG minimum. Bury at least 30 inches below grade.

- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors, unless otherwise indicated.
  - 3. Connections to Ground Rods at Test Wells: Welded or Bolted connectors.
  - 4. Connections to Structural Steel: Welded connectors.

### 3.2 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.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose.

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1. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals.
  2. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- F. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
  2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- G. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

### 3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
  2. For grounding electrode system, install rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12 inches deep, with cover.
1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- D. 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 so vibration is not transmitted to rigidly mounted equipment.
  3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

## GROUNDING AND BONDING

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- E. Grounding and Bonding for Piping:
  - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Bond grounding electrodes described in 2.3.1.D indicated on Drawings to form a Grounding Electrode System.

### 3.4 FIELD QUALITY CONTROL

- A. Engage independent testing agency to 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, and at ground test wells.
    - 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.
- B. Report measured ground resistances that exceed the following values:
  - 1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
  - 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
  - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
  - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm.
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

### END OF SECTION



**SECTION 26 05 29**  
**HANGERS AND SUPPORTS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes:
  - 1. Hangers and supports for electrical equipment and systems.
  - 2. Construction requirements for concrete bases.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For steel slotted support systems.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
  - 1. Trapeze hangers. Include Product Data for components.
  - 2. Steel slotted channel systems. Include Product Data for components.
  - 3. Equipment supports.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Welding certificates.

**1.4 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

**PART 2 - PRODUCTS**

**2.1 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. 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.

## 2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Cooper B-Line, Inc.; a division of Cooper Industries.
    - b. Thomas & Betts Corporation.
    - c. Unistrut; Tyco International, Ltd.
  - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
  - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
  - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Hilti Inc.
      - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

- 3) MKT Fastening, LLC.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
    - 2) Empire Tool and Manufacturing Co., Inc.
    - 3) Hilti Inc.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

### 2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials:
  1. Comply with requirements in Division 05 Section 05 55 00 "Metal Fabrications" for steel shapes and plates.
  2. Comply with requirements in Division 05 Section 05 43 00 "Slotted Channel Framing" for unistrut systems.

## PART 3 - EXECUTION

### 3.1 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 its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch 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.

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

### 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and bolt to expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Bolt to expansion anchor fasteners.
  - 5. Instead of expansion anchors, and only with written owner approval on an application-by-application basis, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
  - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69, or Spring-tension clamps.
  - 7. To Light Steel: Sheet metal screws.
  - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Sections 05 55 00 "Metal Fabrications" and 05 43 00 "Slotted Channel Framing" for site-fabricated metal framing and supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches 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, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
  - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

### 3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

## END OF SECTION

**SECTION 26 05 33**  
**RACEWAYS AND BOXES**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes:
  - 1. Raceways.
  - 2. Fittings.
  - 3. Boxes.
  - 4. Enclosures.
  - 5. Cabinets for electrical wiring.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

**1.3 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.

**PART 2 - PRODUCTS**

**2.1 METAL CONDUIT AND TUBING**

- A. Rigid Steel Conduit: ANSI C80.1.
- B. IMC: ANSI C80.6.
- C. EMT: ANSI C80.3.
- D. FMC: Zinc-coated steel (Aluminum is not permitted)
- E. LFMC: Flexible steel conduit with PVC jacket.

- F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
  - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
  - 2. Fittings for EMT: Steel, compression type.

## 2.2 NONMETALLIC CONDUIT AND TUBING

- A. ENT: NEMA TC 13.
- B. RNC: NEMA TC 2, Type EPC-40-PVC unless otherwise indicated.
- C. LFNC: UL 1660.
- D. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- E. Fittings for LFNC: UL 514B.

## 2.3 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper B-Line, Inc.
  - 2. Hoffman.
  - 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 for interior applications, or 3R for exterior or wet applications, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type, or as indicated.
- E. Finish: Manufacturer's standard enamel finish.

## 2.4 NONMETALLIC WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Hoffman.
  - 2. Lamson & Sessions; Carlon Electrical Products.
- B. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

## 2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Thomas & Betts Corporation.
    - b. Walker Systems, Inc.; Wiremold Company (The).
    - c. Wiremold Company (The); Electrical Sales Division.
- B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Hubbell Incorporated; Wiring Device-Kellems Division.
    - b. Panduit Corp.
    - c. Walker Systems, Inc.; Wiremold Company (The).

## 2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.
- C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.
- E. Nonmetallic Floor Boxes: Nonadjustable, round.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum or galvanized with gasketed cover.
- H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures: Plastic.
- I. Cabinets:
  - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.



2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

## 2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

### A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

### C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of fiberglass.

1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

## PART 3 - EXECUTION

### 3.1 RACEWAY APPLICATION

- #### A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit or IMC.

2. Concealed Conduit, Aboveground: Rigid steel conduit, IMC, EMT, or RNC Type EPC-40-PVC.
  3. Underground Conduit: RNC, Type EPC-40 or 80-PVC, direct buried.
  4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R or as specified.
- B. Indoors: Comply with the following indoor applications, unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT, ENT or RNC.
  2. Exposed, Not Subject to Severe Physical Damage: EMT or RNC identified for such use.
  3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit, IMC. Includes raceways in the following locations:
    - a. Loading dock.
    - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    - c. Mechanical rooms.
  4. Concealed in Ceilings and Interior Walls and Partitions: EMT, ENT, or RNC, Type EPC-40-PVC.
  5. With written permission of the Owner, FMC may be used in existing walls. FMC must be transitioned to EMT, ENT, or RNC as soon as possible after the FMC exits the wall.
  6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, and use LFMC in damp or wet locations.
  7. Damp or Wet Locations: Rigid steel conduit, IMC.
  8. Raceways for Optical Fiber or Communications Cable: EMT or ENT
  9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel or nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings:
1. Rigid Steel and IMC: Use threaded rigid steel conduit fittings or compression couplings, unless otherwise indicated. Screw couplings are not permitted.
- 3.2 INSTALLATION
- A. Comply with NECA 1 for installation more stringent requirements are indicated.
  - B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
  - C. Complete raceway installation before starting conductor installation.
  - D. Support raceways as specified in Division 26 Section 26 05 29 "Hangars and Supports."

- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed. For 18 Gauge conductors the maximum 90-degree bends shall be three for 200 ft conduit run, for longer than 200 ft conduit run the maximum number of 90-degree bends shall be two. Any conductors smaller than 18 gauge the maximum 90 degree bends shall be two.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Conduits installed horizontally to supply in-wall devices shall not be installed within the wall. The conduit shall be brought vertically to above the wall and the horizontal section(s) shall be installed above the top of the wall and then transition vertically down to the device. Devices within adjacent wall chases may be connected horizontally through the wall.
- I. Raceways Embedded in Slabs:
  - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
  - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
  - 3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install as follows:
  - 1. 3/4-Inch Trade Size (no 1/2-inch or 3/8-inch allowed) and Smaller: Install raceways in maximum lengths of 50 feet.
  - 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
  - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. Where otherwise required by NFPA 70.

- N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
  - 1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
    - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    - c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.
    - d. Attics: 135 deg F temperature change.
  - 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
  - 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
- O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
  - 1. Use LFMC in damp or wet locations subject to severe physical damage.
  - 2. Use LFMC in damp or wet locations not subject to severe physical damage.
- P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall.
- Q. Set metal floor boxes level and flush with finished floor surface.
- R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

### 3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
  - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section 31 20 00 "Earth Moving."
  - 2. for pipe less than 6 inches in nominal diameter.
  - 3. Install backfill as specified in Division 31 Section 31 20 00 "Earth Moving."
  - 4. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process.
    - a. Firmly hand tamp backfill around conduit to provide maximum supporting strength.
    - b. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section 31 20 00 "Earth Moving."

5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Warning Tape: Bury warning tape approximately 12 inches above direct-buried conduits.

### 3.4 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section 07 84 13 "Penetration Firestopping."

**END OF SECTION**

**SECTION 26 05 36**  
**CABLE TRAYS FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This Section includes 18" wide 6" deep aluminum cable trays and accessories for communications systems cabling.

**1.2 SUBMITTALS**

- A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

**1.3 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.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. 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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Chalfant Manufacturing Company.
  - 2. Cooper B-Line, Inc.
  - 3. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.
  - 4. GS Metals Corp.; GLOBETRAY Products.
  - 5. MONO-SYSTEMS, Inc.
  - 6. MPHusky.

7. PW Industries.

## 2.2 MATERIALS AND FINISHES

- A. 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 chromium-zinc, ASTM F 1136 or Type 316 stainless-steel splice-plate fasteners, bolts, and screws.
- B. 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.

## 2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

## 2.4 WARNING SIGNS

- A. Lettering: 1-1/2-inch-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 26 05 53 "Identification for Electrical Systems."

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with recommendations in NEMA VE 2. Install as a complete system, including necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
- B. Remove burrs and sharp edges from cable trays.
- C. Fasten cable tray supports to building structure and install seismic restraints.
  - 1. Design each fastener and support to carry load indicated by seismic requirements.
  - 2. Place supports so that spans do not exceed maximum spans on schedules.
  - 3. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
  - 4. Support bus assembly to prevent twisting from eccentric loading.

5. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
  6. Locate and install supports according to NEMA VE 1.
- D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
  - E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.
  - F. Make changes in direction and elevation using standard fittings.
  - G. Make cable tray connections using standard fittings.
  - H. Seal penetrations through fire and smoke barriers according to Division 07 Section 07 84 13 "Penetration Firestopping."
  - I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
  - J. Workspace: Install cable trays with enough space to permit access for installing cables.
  - K. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.
  - L. Install cables only when cable tray installation has been completed and inspected.
  - M. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. 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.
  - N. On vertical runs, fasten cables to tray every 18 inches. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
  - O. Install covers after installation of cable is completed.
  - P. Ground cable trays according to manufacturer's written instructions.
  - Q. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

### 3.2 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
  1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.

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2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
  3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
  4. Remove deposits of dust, industrial process materials, trash of description, and blockage of tray ventilation.
  5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
  6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
  7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that takeoff raceways are bonded to cable tray.
- B. Report results in writing.

**END OF SECTION**

## SECTION 26 05 44

### SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

#### PART 1 - GENERAL

##### 1.1 SUMMARY

###### A. Sections Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

###### B. Related Requirements:

1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

##### 1.2 ACTION SUBMITTALS

- ###### A. Product Data: For each type of product.

#### PART 2 - PRODUCTS

##### 2.1 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 waterstop 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. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

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

- ###### E. Sleeves for Rectangular Openings:

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

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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).

## 2.2 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.

## 2.3 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.
  2. Sealant shall have VOC content of  $<20\text{g} > \text{g/L}$  or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

## PART 3 - EXECUTION

### 3.1 SLEEVE INSTALLATION FOR NON- 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:

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- a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
  - 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
  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.
- ### 3.2 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.
- ### 3.3 SLEEVE- SEAL- FITTING INSTALLATION
- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

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- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop 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**

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*Last Updated:*

*April 2022*

## SECTION 26 05 53

### IDENTIFICATION FOR ELECTRICAL SYSTEMS

#### PART 1 - GENERAL

##### 1.1 SUMMARY

###### A. Section Includes:

1. Identification for raceways, conduits, enclosures, and boxes.
2. Identification for conductors, power and control cables.
3. Circuit identification on switch covers and receptacles covers
4. Warning labels, signs, and underground warning tape.
5. Instruction signs.
6. Equipment identification labels.

##### 1.2 ACTION SUBMITTALS

- A. Product Data for each electrical identification product indicated.

##### 1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and NFPA 70.
- B. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- C. Comply with ANSI Z535.4 for safety signs and labels.

#### PART 2 - PRODUCTS

##### 2.1 RACEWAYS (<600V), ARMORED OR METAL CLAD CABLES, AND CONTROL CABLES IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

<b>Pipe O.D.</b>	<b>Min Letter Ht.</b>
Inches	Inches
3/4 to 1 1/4	1/2
1 1/2 to 2	3/4
2 1/2 to 6	1.25
8 to 10	2.5
over 10	3.5

- B. Colors:
  - 1. Black letters on a white field.
  - 2. Legend: Indicate voltage and circuit or service.
- C. 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.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

## 2.2 CONDUCTOR IDENTIFICATION MATERIALS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification machine printed by thermal transfer or equivalent process.

## 2.3 FLOOR MARKING TAPE

- A. 2-inch wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

## 2.4 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
  - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
  - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
  - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- B. Color and Printing:
  - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
  - 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
  - 3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

## 2.5 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.

- B. 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.
- C. Baked-Enamel Warning Signs:
  - 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
  - 2. 1/4-inch grommets in corners for mounting.
  - 3. Nominal size, 7 by 10 inches.
- D. Warning label and sign shall include, but are not limited to, the following legends:
  - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
  - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES"

## 2.6 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick.
  - 1. Engraved legend with white letters on black face.
  - 2. Punched or drilled for mechanical fasteners.
  - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 1/2 inch.
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 1/2 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

## 2.7 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear or White Background: Machine printed, black letters, by thermal transfer or equivalent process. Minimum letter height shall be 1/2 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a black background. Minimum letter height shall be 1/2 inch.



## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding 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 maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.
- G. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

### 3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 20A, and 120V to ground: Label each end.
- B. Accessible Raceways and Cables within Buildings: On the covers of each junction and pull box of the following systems mark with self-adhesive vinyl labels or permanent black marker. Write the circuit ID, system voltage and wiring system legend. System legends shall be as follows:
  - 1. Emergency Power.
  - 2. UPS.
  - 3. Power (for normal power mark circuit ID and system voltage only)
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
  - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
    - a. Color shall be factory applied.
    - b. Colors for 208/120-V Circuits:

- 1) Phase A: Black.
  - 2) Phase B: Red.
  - 3) Phase C: Blue.
  - 4) Neutral: White
  - 5) Ground: Green
- c. Colors for 480/277-V Circuits:
- 1) Phase A: Brown.
  - 2) Phase B: Orange.
  - 3) Phase C: Yellow.
  - 4) Neutral: Gray
  - 5) Ground: Green
- d. 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.
- D. Install instructional sign including the color code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Conductors to Be Extended in the Future: Attach write-on tags or marker tape to conductors and list source.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal 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 the Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
- H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures. Self-adhesive warning labels or Acrylic or Melamine warning signs.
1. Identify system voltage with white letters on a black background
  2. Apply to exterior of door, cover, or other access.
  3. For 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.

- J. Warning Labels for Outdoor Cabinets, Boxes, Enclosures, and Equipment: Acrylic or Melamine only.
  - 1. Identify system voltage with white letters on a black background
  - 2. Apply to exterior of door, cover, or other access.
  - 3. For 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.
- K. Switch and Receptacle Covers: Black letter on a white or clear self-adhesive label machine tape. Minimum 3/8-inch high letters.
- L. Operating Instruction Signs: 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.
- M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 1/2-inch high letters for emergency instructions at equipment used for power transfer, load shedding or other emergency operation.
- N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams and/or schedules (e.g. CU-1). 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 has its own identification.
  - 1. Labeling Instructions:
    - a. Indoor Equipment: Adhesive film label, Adhesive film label with clear protective overlay, or Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
    - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label, lettering 1 inches high.
    - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
    - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

**END OF SECTION**

## SECTION 26 08 00

### COMMISSIONING OF ELECTRICAL SYSTEMS

#### PART 1 - GENERAL

##### 1.1 SUMMARY

###### A. Sections Include:

1. This section specifies the unique responsibilities that are a part of or are related to the commissioning process for the electrical systems. Electrical systems include those listed in Division 01 Section "General Commissioning Requirements" as being commissioned. Statements are the responsibility of the Subcontractor, unless specifically stated otherwise.
2. Electrical testing specified for systems not listed as formally commissioned are not under the commissioning umbrella and are not governed by this section.
3. Electrical Systems Commissioning consists of static checks of component and system installations and actual testing of equipment conditions and functions.
4. The Commissioning Authority will review and approve, prior to use, test procedures and forms used and will witness a varying fraction of the initial checks and testing performed by the Subcontractor. The Commissioning Authority will review the completed check and test documentation of the Subcontractor of checks and tests.
5. Electrical testing requirements are found in various sections in Division 01 and in Division 26 (Division 01 Section "General Commissioning Requirements" and this section). It is not the intent of the commissioning process or these specifications to duplicate efforts or to require the Subcontractor to perform check or test twice. Checks and testing by the Subcontractor are expected to occur once in the normal sequence of installation and checkout, if appropriate coordination has occurred allowing the Owner and the Commissioning Authority to witness installations and initial testing. Identical electrical checks and testing requirements in both Division 01 and Division 26 are referring to the same event.
6. The test requirements listed in this section do not release the Subcontractor from the obligation to perform other appropriate, industry standard, manufacturer-recommended or code-required checks and tests.
7. Testing Participants. The work of this section shall be performed by parties identified in the Check and Testing Responsibility Table--a supplement to Division 01 Section "General Commissioning Requirements". Static checks and testing shall be fully documented according to provisions in Division 01 Section "General Commissioning Requirements".

###### B. Related Sections:

1. Division 01 Section "General Requirements."
2. Division 01 Section "Special Procedures."
3. Division 01 Section "General Commissioning Requirements".

### COMMISSIONING OF ELECTRICAL SYSTEMS

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## 1.2 SUBMITTALS

- A. Submit under provisions of Divisions 01 Section "General Requirements" and "Special Procedures."

## 1.3 QUALITY ASSURANCE

- A. Qualifications:
  - 1. The CTC (Certified Testing Company) performing the work of this section shall be qualified to test electrical equipment and is a NETA (National Electrical Testing Association)-certified testing agency. The CTC shall not be associated with the manufacturer of equipment or systems under test.
- B. Test Equipment:
  - 1. The Subcontractor shall provide test equipment necessary to fulfill the checks and testing requirements. Test equipment shall have been calibrated within one (1) year of its use on the project.
  - 2. Refer to Division 01 Section "General Commissioning Requirements" for additional requirements.

## PART 2 - PRODUCTS NOT USED

## PART 3 - EXECUTION

### 3.1 SUBMITTALS

- A. Before testing is conducted, submit an overall testing plan and schedule for electrical systems that lists the equipment, modes to be tested, dates of testing and parties conducting the tests. Put these tests into the master construction schedule. Keep this plan and schedule updated.
- B. Additional submittal requirements relative to commissioning are found in this Section and in Division 01 Section "General Commissioning Requirements" and Division 01 Section "General Requirements."

### 3.2 COMMON RESPONSIBILITIES

- A. The following are responsibilities applicable to electrical systems being commissioned.
- B. The general commissioning requirements and coordination are detailed in Division 01 Section "General Commissioning Requirements" and apply to electrical systems. The Subcontractor shall be familiar with parts of Division 01 Section "General Commissioning Requirements" and the commissioning plan issued by the Commissioning Authority and shall execute commissioning responsibilities assigned to them in the Contract Documents.

- C. The work of this Section shall be performed by a CTC (Certified Testing Company, Electrical), by the EC (Electrical Subcontractor), or the MSR (Manufacturer's Service Representative). The Commissioning Authority has some testing responsibilities for some equipment. The specified checks and static tests are conducted by of the above listed parties, but the tests requiring measurements or special tools or skills are generally conducted only by the CTC. The Check and Testing Responsibility Table, included as a supplement to Division 01 Section "General Commissioning Requirements" provides specific allocation of checklist oversight and testing responsibilities. The CTC, EC, and MSR shall document checks and testing on check and test procedure forms submitted to and approved by the Commissioning Authority prior to testing.
- D. The Subcontractor shall notify the Owner ahead of time when commissioning activities not yet performed or not yet scheduled will delay construction. The Subcontractor shall be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.
- E. The Subcontractor shall respond to notices of issues identified during the commissioning process, making required corrections or clarifications and returning prompt notification to the Commissioning Authority according to the process given in Division 01 Section "General Commissioning Requirements".
- F. When completion of a task or other issue has been identified as holding up commissioning process, particularly functional testing, the Subcontractor shall, within two (2) days of notification of the issue, notify the Commissioning Authority in writing providing an expected date of completion. The Subcontractor shall notify the Commissioning Authority in writing within one day of completion. It is not the responsibility of the Commissioning Authority to obtain this status information through meeting attendance, asking questions or field observation
- G. Construction Checklists. The Commissioning Authority or Subcontractor shall develop checklists as noted in the list of commissioned systems in Division 01 Section "General Commissioning Requirements", following the process described in Division 01 Section "General Commissioning Requirements" and in this Section. At a minimum, for a given piece of equipment, checks from the inspection checklists in NETA Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems shall be included in the electrical checklists. The Subcontractor shall execute and document checks.
- H. Check and testing procedure and startup plan development and execution responsibilities are described in the Check and Testing Responsibility Table in the supplements to Division 01 Section "General Commissioning Requirements".
- I. The Subcontractor shall review design documents, shop drawings and O&M manuals and manufacturer recommended installation and testing procedures of each system installation.
- J. The Subcontractor shall monitor installation to ensure the equipment, configuration and quality of construction meets the design requirements, approved submittals and shop drawings.
- K. The Subcontractor shall develop test procedures and forms and execute and document testing according to the requirements of this Section, Division 01 Section "General

Commissioning Requirements" and other specification sections containing testing requirements.

- L. Tests of energized equipment shall be conducted when the equipment is operating at its normal capacity. This may require some tests to be conducted after occupancy.
- M. Training and Orientation. The Subcontractor shall follow the facility staff orientation and training requirements as described in Division 01 Section "Demonstration and Training" and other applicable technical sections.
- N. Operation And Maintenance (O&M) Manuals. Refer to Division 01 Section "General Commissioning Requirements" and Division 01 Section "General Requirements" for requirements for O&M manuals.

## PART 4 - EQUIPMENT-SPECIFIC VERIFICATION AND TESTING REQUIREMENTS

### 4.1 SUMMARY

- A. This Part specifies the check and testing requirements for electrical components and systems. From these requirements, the Commissioning Authority or Subcontractor will develop detailed procedures and forms. The general testing process, requirements and test method definitions are described in Division 01 Section "General Commissioning Requirements".

### 4.2 CHECKS AND TESTS

- A. Checks are intended to begin upon completion of a component or equipment installation. Testing generally occurs later when systems are energized or nearing that point. Beginning system testing before full completion, does not relieve the Subcontractor from fully completing the system as soon as possible, including construction checklists and may require retesting portions of the system once components are fully functioning.
- B. Refer to Division 01 Section "General Commissioning Requirements" for specific details on non-conformance issues relating to construction checklists and tests. Refer to Division 01 Section "General Commissioning Requirements", for common requirements of deferred testing and to articles in this Section.
- C. The check and test procedures and record forms shall contain the following:
  - 1. The Subcontractors executing the checks or tests.
  - 2. A list of the integral components being inspected and tested, equipment tag numbers, manufacturer, model number, pertinent performance information / rating data.
  - 3. Test equipment used.
  - 4. Construction checklists associated with the components.
  - 5. Special required conditions of the check or test for each procedure.
  - 6. Items, conditions or functions to be inspected, verified or tested, the checks and testing method given and a place provided with results recorded.

7. Acceptance criteria (or reference by specific table where the acceptance criteria is found).
  8. For each procedure, list the technician performing check or test and company, witnesses of the tests and dates of tests.
  9. Sampling strategies used.
- D. The test procedures for dynamic equipment like lighting controls, emergency generator or fire alarm shall contain more step-by-step procedures with expected responses similar to the sample test provided as a supplement to Division 01 Section "General Commissioning Requirements". The test procedures and forms for more static components like panel boards, switch gear, circuit breakers, transformers, etc., can be more checklist-like in format. For each piece of equipment, checks and test procedures and their documentation record forms may be different documents or combined in the same document, but checks and tests should be grouped.
- E. At the Commissioning Authority's discretion, if large numbers or repeated deficiencies are encountered, the Subcontractor shall test and troubleshoot remaining systems at issue on their own before commissioning with the Commissioning Authority will resume.
- F. Sampling for Identical Units. When there are a number of identical units, at the Commissioning Authority's discretion, some or procedures of a test for a piece of equipment or assembly may be omitted when these same tests on other pieces of identical equipment or assemblies were conducted without deficiency.

#### 4.3 EQUIPMENT SPECIFIC TESTING REQUIREMENTS

- A. The following paragraphs define the testing requirements for each type of system or feature that is a part of the project. The Commissioning Authority shall use this information to develop specific testing procedures for each of the systems to be commissioned. The Subcontractor shall be responsible for support, execution and coordination of these tests as described in the project specifications including intersystem tests and interlocks with systems in Divisions other than Division 26.
- B. The Commissioning Authority and Subcontractor shall coordinate with the project LEED coordinator to verify that LEED requirements for testing electrical systems are included in the tests.
- C. Common Testing Requirements:
1. The following requirements apply to electrical systems and features that are to be commissioned when referenced below. Tests shall:
    - a. Verify functionality and compliance with the design intent for each individual sequence module in the sequences of operation. Verify proper operation of control strategies, energy efficiency and self-diagnostics features by stepping through each sequence and documenting equipment and system performance. Test every step in every written sequence and other significant modes, sequences and operational features not mentioned in written sequences; including startup, normal operation, shutdown, scheduled on and off, unoccupied and manual modes, safeties, alarms, over-rides, lockouts and power failure.



- b. Verify alarm and high and low limit functions and messages generated on points with alarm settings.
  - c. Verify integrated performance of components and control system components, including interlocks and interactions with other equipment and systems.
  - d. Verify shut down and restart capabilities both for scheduled and unscheduled events (e.g. power failure recovery and normal scheduled start/stop).
  - e. When applicable, demonstrate a full cycle from off to on and no load to full load and then to no load and off.
  - f. Verify time of day schedules and setpoints.
  - g. Verify energy saving control strategies.
  - h. Verify that monitoring system graphics are representative of the systems and that points and control elements are in the same location on the graphic as they are in the field.
  - i. Verify operator control of commandable control system points including proper security level access.
  - j. When testing procedures for commissioned equipment are listed in NETA Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems the NETA test procedures shall be part of the testing requirements of this specification. Additional testing procedures may be listed in this specification.
  - k. Common Acceptance Criteria
2. The following common acceptance criteria apply to mechanical equipment, assemblies and features:
- a. For the conditions, sequences and modes tested, the equipment, integral components and related equipment shall respond to varying loads and changing conditions and parameters appropriately as expected, according to the sequences of operation, as specified, according to acceptable operating practice and the manufacturer's performance specifications. Verify that equipment operates within tolerances specified in: governing codes, acceptance criteria contained in the construction documents, manufacturer's literature and according to good operating practice.
  - b. Systems shall accomplish their intended function and performance.
  - c. Safety trips shall require a manual reset to allow a system restart.
  - d. Resetting a manual safety shall result in a stable, safe, and predictable return to normal operation by the system.
  - e. Safety circuits and permissive control circuits shall function in possible combinations of selector switch positions (hand, auto, inverter, bypass, etc.).
  - f. Other acceptance criteria is given in the equipment testing requirements articles or referenced standards.
  - g. Additional acceptance criteria will be developed by the Commissioning Authority when detailed test procedures are developed.
  - h. When testing procedures for commissioned equipment are listed in NETA Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems the NETA performance criteria shall apply.
- D. Equipment-Specific Testing Requirements:
- 1. Scheduled Lighting Controls:
    - a. Apply the applicable common testing requirements and acceptance criteria.

- b. Test Methods. Utilize active testing, and trending when available. If able to trend, trend zones over a week period and follow the trending guidelines in Division 23 Section "Commissioning of HVAC".
  - c. Sampling Strategy. Manually test 20 percent of the zones or at least four. If more than 10 percent or two zones fail, test another 10 percent sample. If the second sample fails the Subcontractor shall document retesting on zones on their own using a Commissioning Authority approved form.
2. Occupancy Sensor Lighting Controls.
- a. Apply applicable common testing requirements and acceptance criteria. Test units functions, including sensor sensitivity and time-to-OFF functions and ensure that sensor location is proper and won't be tripped inadvertently by other occupants and movements outdoors, etc.
3. Test Methods. Utilize active test methods.
- a. Sampling Strategy. Test 10 percent of the sensors or six, whichever is greater. If more than 10 percent or two sensors fail, test another 10 percent sample. If the second sample fails the Subcontractor shall document retesting on units on their own using a Commissioning Authority approved form.
  - b. Additional Acceptance Criteria. Reasonable sensitivity, no inadvertent trips, lights go off within 15 seconds of design.
4. Emergency Generator System
- a. Apply applicable common testing requirements and acceptance criteria.
  - b. Test according to NETA 7.22.1 and NFPA 110 5.13 and per Division 01 Section "Special Procedures."
  - c. Record data and results.
  - d. Include the following tests:
    - 1) When in enclosed spaces, verify combustion and ventilation air damper functions and pressure drop of exhaust.
    - 2) Verify fuel oil system, diesel fuel storage tank, and level and low fuel indication alarms.
    - 3) Verify alarms, meters, and auxiliaries and interlocks to the BAS.
  - e. Building Test. Under a cold generator condition, provide full utility power interruption under load and cause emergency power service operation. Include UPS in this test. Load bank the UPS if necessary during test.
  - f. Verify generator functions
  - g. Test auto-transfer switch operation under actual voltage drop, per specification Division 26 Section "Automatic Transfer Switch with Bypass-Isolation Feature".
  - h. Using a power line disturbance monitor, measure the following times: power failure to engine start command, engine start command to engine start (cranking time), engine start to point where generator is at proper volts and frequency and total time from power failure until ATS switches.
  - i. Verify system reporting & control monitoring point-to-point
  - j. Verify that each circuit and equipment served by emergency power, does power up. Verify functions of the Emergency Power Response Matrix.
  - k. Verify appropriate mechanical system and control system restart functions of equipment served by the generator.
5. Step Load Tests:
- a. Test at 0 percent, 25 percent, 50 percent and 100 percent of full load. Measure voltage and frequency and record gaged engine conditions. The

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- test shall consist of running the the engine-generator while connected to the resistive load bank for one hour, and then shutting down for 30 minutes.
- b. Test for multiple generator starts.
  - c. Verify operational data and start-up minimum time interval.
  - d. Verify 2-hour full load run full load bank (building load can serve as part of the load).
  - e. Verify generator-running characteristics.
  - f. Verify battery-charging system.
6. Uninterruptible Power Supply.
- a. Apply applicable common testing requirements and acceptance criteria.
  - b. Test according to NETA 7.22.2 and NFPA 111-2001 5.6.
  - c. Test the UPS during the Integrated Building Test in the Emergency Generator System test requirements article in this Section.
7. Fire Alarm:
- a. Apply applicable common testing requirements and acceptance criteria.
  - b. Test the fire alarm and High Sensitivity Smoke Detection systems according to NFPA 110-1999 7-1 through 7-2, and specification Division 28 Sections "High Sensitivity Air Sampling Smoke Detection System" and "MXL Fire Detection & Alarm System".
  - c. Document test procedures and results. A fire alarms system printout of the test annunciation record is not sufficient documentation.
  - d. Verify fire alarm panel functions, alarms and troubles.
  - e. Verify functions in the Fire Alarm Response Matrix, including remote communications.
  - f. Verify resetting of equipment affected by an alarm.
  - g. Sampling Strategy. Verify device functions and annunciations per using the approved sampling rate of the authority having jurisdiction and per LBNL.

**END OF SECTION**

## SECTION 26 09 13

### ELECTRICAL POWER MONITORING

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes the following for monitoring of electrical power system:
  - 1. PC-based workstation and software.
  - 2. Communication network and interface modules for RS-485, Modbus TCP/IP data transmission protocols.

##### 1.2 DEFINITIONS

- A. Ethernet: Local area network based on IEEE 802.3 standards.
- B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
- C. HTML: Hypertext markup language.
- D. I/O: Input/output.
- E. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.
- F. LAN: Local area network; sometimes plural as "LANs."
- G. LCD: Liquid crystal display.
- H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
- I. Modbus TCP/IP: An open protocol for exchange of process data.
- J. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- K. PC: Personal computer; sometimes plural as "PCs."
- L. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

- M. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.
- N. RS-485: A TIA standard for multipoint communications using two twisted-pairs.
- O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- P. THD: Total harmonic distortion.
- Q. UPS: Uninterruptible power supply; used both in singular and plural context.
- R. WAN: Wide area network.

### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
  - 1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
- B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.
  - 2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
  - 3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
  - 5. UPS sizing calculations for workstation.
  - 6. Surge Suppressors: Data for each device used and where applied.

### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordinate first paragraph below with qualification requirements in Section 01 40 00 "Quality Requirements" and as supplemented in "Quality Assurance" Article.
- B. Qualification Data: For qualified Installer.
- C. Field quality-control reports.
- D. Other Informational Submittals:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
  1. Operating and applications software documentation.
  2. Software licenses.
  3. Software service agreement.
  4. PC installation and operating documentation, manuals, and software for the PC and installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for installed hardware. Provide separately for each PC.
  5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
- B. Software and Firmware Operational Documentation:
  1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from PC on the network, using a standard Web browser; and recommended firewall setup.
  2. Software operating and upgrade manuals.
  3. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.
  4. Device address list and the set point of each device and operator option, as set in applications software.
  5. Graphic file and printout of graphic screens and related icons, with legend.
- C. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.
- D. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

## 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.
- 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.

## 1.7 COORDINATION

- A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
  - 1. Match components and interconnections for optimum performance of specified functions.
- B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

## 1.8 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 the operating systems. 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.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Corporation; Cutler-Hammer products.
  - 2. General Electric Company; GE Consumer & Industrial.
  - 3. Siemens Technologies
  - 4. Schneider Electric - Power Management Operation.

### 2.2 FUNCTIONAL DESCRIPTION

- A. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.
  - 1. Calculate and Record the Following:
    - a. Load factor.
    - b. Peak demand periods.
    - c. Power factor.
  - 2. Measure and Record Metering Data for the Following:
    - a. Electricity
- B. Software: Calculate allocation of utility costs.
  - 1. Automatically Import Energy Usage Records to Allocate Energy Costs for the Following:

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- a. At least 30 distribution points.
- C. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:
  - 1. Voltage regulation and unbalance.
  - 2. Continuous three-phase rms voltage.
  - 3. Periodic max./min./avg. voltage samples.
  - 4. Harmonics.
  - 5. Voltage excursions.
  - 6. Power factor
  - 7. Continuous three phase rms current
  - 8. Periodic max./min./avg. current samples

## 2.3 SYSTEM REQUIREMENTS

- A. Monitoring System: Include PC-based workstation with its operating system and application software, connected to data transmission network.
- B. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
  - 1. Minimum Protection for Power Lines 120 V and More.
  - 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
- C. Addressable Devices: Transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.
- D. BAS Interface: Provide factory-installed hardware and software to enable the BAS to monitor, display, and record data for use in processing reports.
  - 1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor, voltage and current.
  - 2. ASHRAE 135 (BACnet) communication interface with the BAS shall enable the BAS operator to remotely monitor meter information from a BAS operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the BAS.

## 2.4 OPERATING SYSTEM

- A. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.
- B. Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Modbus TCP/IP, RS-232, and RS-485 digital communications.



- C. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Ethernet, Modbus TCP/IP, RS-232, and RS-485 digital communications.
- D. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.
- E. Operating System Software: Based on 64-bit, Microsoft Windows workstation operating system. Software shall have the following features:
  - 1. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
  - 2. Graphical user interface to show pull-down menus and a menu tree format.
  - 3. Capability for future additions within the indicated system size limits.
- F. Peer Computer Control Software: Shall detect a failure of workstation and shall cause other workstation to assume control of system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.

## 2.5 APPLICATIONS SOFTWARE

- A. Basic Requirements:
  - 1. Fully compatible with and based on the approved operating system.
  - 2. Password-protected operator login and access; three levels, minimum.
  - 3. Password-protected setup functions.
  - 4. Context-sensitive online help.
  - 5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of files, including size and location of each sequential and random-ordered record.
  - 6. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
  - 7. Automatic and encrypted backups for database and history; automatically stored at selected workstation and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
  - 8. Operator audit trail for recording and reporting changes made to user-defined system options.
- B. Data Formats:
  - 1. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
  - 2. Option to convert reports and graphics to HTML format.
  - 3. Interactive graphics.
  - 4. Option to send preprogrammed or operator designed e-mail reports.

- C. Metered Data: Display metered values in real time.
- D. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
  - 1. Operator log on/off.
  - 2. Attempted operator log on/off.
  - 3. Alarms.
  - 4. Out-of-limit, pickup, trip, and no-response events.
- E. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
  - 1. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
  - 2. Charting, statistical, and display functions of standard Windows-based spreadsheet.
- F. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
  - 1. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.
- G. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event. Include the graphic displays of the following, based on user-specified criteria:
  - 1. Phase voltages, phase currents, and residual current.
  - 2. Overlay of three-phase currents and overlay each phase voltage and current.
  - 3. Waveforms ranging in length from 2 cycles to 5 minutes.
  - 4. Disturbance and steady-state waveforms up to 512 points per cycle.
  - 5. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
  - 6. Calculated waveform, based on recorded data, on a minimum of four cycles of data of the following:
    - a. THD.
    - b. rms magnitudes.
    - c. Peak values.
    - d. Crest factors.
    - e. Magnitude of individual harmonics.
- H. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
  - 1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
  - 2. Sort and report by device name and by function.
  - 3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
  - 4. Differentiate alarm signals from other indications.

5. When system is reset, report reset event with same information concerning device, location, date, and time.

I. Display Monitor:

1. Backlighted LCD to display metered data with touch-screen selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.

## 2.6 COMMUNICATION COMPONENTS AND NETWORKS

- A. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.

## 2.7 POWER MONITORS

- A. Separately mounted, permanently installed instrument for power monitoring and control, complying with UL 1244.

1. Enclosure: NEMA 250, Type 1.

- B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in non-temperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.

- C. rms Real-Time Measurements:

1. Current: Each phase, neutral, average of three phases, percent unbalance.
2. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
3. Power: Per phase and three-phase total.
4. Reactive Power: Per phase and three-phase total.
5. Apparent Power: Per phase and three-phase total.
6. Power Factor: Per phase and three-phase total.
7. Displacement Power Factor: Per phase and three-phase total.
8. Frequency.
9. THD: Current and voltage.
10. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
11. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
12. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

- D. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:

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1. Present.
  2. Running average.
  3. Last completed interval.
  4. Peak.
- E. Demand Real Power Calculations, Three-Phase Total:
1. Present.
  2. Running average.
  3. Last completed interval.
  4. Predicted.
  5. Peak.
  6. Coincident with peak kVA demand.
  7. Coincident with kVAR demand.
- F. Demand Reactive Power Calculations, Three-Phase Total:
1. Present.
  2. Running average.
  3. Last completed interval.
  4. Predicted.
  5. Peak.
  6. Coincident with peak kVA demand.
  7. Coincident with kVAR demand.
- G. Demand Apparent Power Calculations, Three-Phase Total:
1. Present.
  2. Running average.
  3. Last completed interval.
  4. Predicted.
  5. Peak.
  6. Coincident with peak kVA demand.
  7. Coincident with kVAR demand.
- H. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:
1. Last completed interval.
  2. Coincident with kW peak.
  3. Coincident with kVAR peak.
  4. Coincident with kVA peak.
- I. Power Analysis Values:
1. THD, Voltage and Current: Per phase, three phase, and neutral.
  2. Displacement Power Factor: Per phase, three phase.
  3. Fundamental Voltage, Magnitude and Angle: Per phase.
  4. Fundamental Currents, Magnitude and Angle: Per phase.

5. Fundamental Real Power: Per phase, three phase.
  6. Fundamental Reactive Power: Per phase.
  7. Harmonic Power: Per phase, three phase.
  8. Phase rotation.
  9. Unbalance: Current and voltage.
  10. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 31st harmonic.
- J. Sampling:
1. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
  2. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on voltage and current channels in the meter.
- K. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
1. Line-to-line voltage.
  2. Line-to-neutral voltage.
  3. Current per phase.
  4. Line-to-line voltage unbalance.
  5. Line-to-neutral voltage unbalance.
  6. Power factor.
  7. Displacement power factor.
  8. Total power.
  9. Total reactive power.
  10. Total apparent power.
  11. THD voltage L-L.
  12. THD voltage L-N.
  13. THD current.
  14. Frequency.
- L. Harmonic Calculation: Display and record the following:
1. Harmonic magnitudes and angles for each phase voltage and current through 31st harmonic. Calculate for three phases, current and voltage, and residual current. Current and voltage information for phases shall be obtained simultaneously from same cycle.
  2. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.
- M. Current and Voltage Ratings:
1. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.

2. Withstand ratings shall not be less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
3. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.

N. Accuracy:

1. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters. Accuracy from Light to Full Rating shall meet the following criteria:
  - a. Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
  - b. Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
  - c. Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.
  - d. Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.
2. For meters that are circuit-breaker accessories, metering accuracy at full-scale shall not be less than the following:
  - a. Current: Plus or minus 2.5 percent.
  - b. Voltage: Plus or minus 1.5 percent.
  - c. Energy, Demand, and Power: Plus or minus 4.0 percent.
  - d. Frequency: Plus or minus 1 Hz.

O. Waveform Capture:

1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.
2. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

P. Onboard Data Logging:

1. Store logged data, alarms, events, and waveforms in 800 KB of onboard nonvolatile memory.
2. Stored Data:
  - a. Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 and 52 days of 15-minute interval data, depending on number of quantities selected.
  - b. Custom Data Logs: One user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:
    - 1) Schedule interval.
    - 2) Event definition.
    - 3) Configured as "fill-and-hold" or "circular, first-in first-out."
  - c. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
  - d. Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."
3. Default values for logs shall be initially set at factory, with logging to begin on device power up.

Q. Alarms:

1. Alarm Events:
  - a. Over/undercurrent.
  - b. Over/undervoltage.
  - c. Current imbalance.
  - d. Phase loss, current.
  - e. Phase loss, voltage.
  - f. Voltage imbalance.
  - g. Over kW demand.
  - h. Phase reversal.
  - i. Digital input off/on.
  - j. End of incremental energy interval.
  - k. End of demand interval.

R. Control Power: 90- to 457-V ac or 100- to 300-V dc.

S. Communications:

1. Power monitor shall be permanently connected to communicate via RS-485 Modbus TCP/IP.
2. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.

T. Display Monitor:

1. Backlighted LCD to display metered data with touch-screen selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.
  - a. Current, per phase rms, three-phase average and neutral.
  - b. Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
  - c. Real power, per phase and three-phase total.
  - d. Reactive power, per phase and three-phase total.
  - e. Apparent power, per phase and three-phase total.
  - f. Power factor, per phase and three-phase total.
  - g. Frequency.
  - h. Demand current, per phase and three-phase average.
  - i. Demand real power, three-phase total.
  - j. Demand apparent power, three-phase total.
  - k. Accumulated energy (MWh and MVARh).
  - l. THD, current and voltage, per phase.
4. Reset: Allow reset of the following parameters at the display:
  - a. Peak demand current.
  - b. Peak demand power (kW) and peak demand apparent power (kVA).
  - c. Energy (MWh) and reactive energy (MVARh).

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 CABLING

- A. Comply with NECA 1.
- B. Install cables and wiring according to requirements in Section 27 15 13 "Communications Copper Horizontal Cabling" and Section 27 15 23 Communications Optical Fiber Horizontal Cabling."
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- E. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.
- F. Install cables without damaging conductors, shield, or jacket.

### 3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."
- B. Label each power monitoring and control module with a unique designation.

### 3.4 GROUNDING

- A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: General Contractor will engage a qualified testing agency to perform tests and inspections.



- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. 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.
- D. Tests and Inspections:
  - 1. Electrical Tests: Use caution when testing devices containing solid-state components.
  - 2. Continuity tests of circuits.
  - 3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.
    - a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
    - b. Test LANs according to requirements in Section 27 15 13 "Communications Copper Horizontal Cabling" and Section 27 15 23 Communications Optical Fiber Horizontal Cabling."
    - c. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
    - d. Verify accuracy of graphic screens and icons.
    - e. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
    - f. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.
- E. Power monitoring and control equipment will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.
- H. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- I. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

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- J. Remove and replace malfunctioning devices and circuits and retest as specified above.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. See Section 01 79 00 "Demonstration and Training."
  - 1. Train Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 8 hours' training.
  - 2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

### 3.7 ON- SITE ASSISTANCE

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

**END OF SECTION**

**SECTION 26 09 23**  
**LIGHTING CONTROL DEVICES**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes the following lighting control devices:
  - 1. Time switches.
  - 2. Outdoor photoelectric switches.
  - 3. Indoor occupancy sensors.
  - 4. Outdoor motion sensors.
  - 5. Lighting contactors.
  - 6. Emergency shunt relay.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

**1.5 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.

**PART 2 - PRODUCTS**

**2.1 TIME SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings:

1. Cooper Industries, Inc.
  2. Intermatic, Inc.
  3. NSI Industries LLC; Tork Products.
  4. Tyco Electronics; ALR Brand.
- C. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
1. Contact Configuration: SPST, DPST or DPDT per the drawing requirements or as indicated on drawings.
  2. Contact Rating: 30-A inductive or resistive, 240-V ac
  3. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
  4. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
  5. Programs: Number of channels as shown on plans; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
  6. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
  7. Astronomic Time: Selected channels, as indicated on plans.
  8. Battery Backup: For schedules and time clock.
- D. Electromechanical-Dial Time Switches: Shall not be used.

## 2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
  2. Intermatic, Inc.
  3. NSI Industries LLC; Tork Products.
  4. Tyco Electronics; ALR Brand.
- B. Description: Solid state, with SPST or DPST as needed dry contacts rated for 1800-VA to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
  2. Time Delay: 30-second minimum, to prevent false operation.
  3. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

## 2.3 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bryant Electric; a Hubbell company.
  2. Cooper Industries, Inc.
  3. Hubbell Building Automation, Inc.
  4. Leviton Mfg. Company Inc
  5. Lithonia Lighting; Acuity Lighting Group, Inc.
  6. Lutron Electronics Co., Inc.
  7. NSI Industries LLC; TORK Products.
  8. RAB Lighting
  9. Sensor Switch, Inc.
  10. Square D; a brand of Schneider Electric.
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
  3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
  4. Mounting:
    - a. Sensor: Suitable for mounting in any position on a standard outlet box.
    - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
  5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
  6. Bypass Switch: Override the on function in case of sensor failure.
  7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.
- C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
  2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
  3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.

## 2.4 OUTDOOR MOTION SENSORS (PIR)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bryant Electric; a Hubbell company.
  2. Cooper Industries, Inc.
  3. Hubbell Building Automation, Inc.
  4. Leviton Mfg. Company Inc.
  5. Lithonia Lighting; Acuity Lighting Group, Inc.
  6. NSI Industries LLC; TORK Products.
  7. RAB Lighting
  8. Sensor Switch, Inc.
  9. Watt Stopper
- B. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as raintight according to UL 773A.
1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  2. Mounting:
    - a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
    - b. Relay: Internally mounted in a standard weatherproof electrical enclosure.
    - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
  3. Bypass Switch: Override the on function in case of sensor failure.
  4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc; keep lighting off during daylight hours.
- C. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
- D. Detection Coverage: As needed based on drawings and field conditions.
- E. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
- F. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
1. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
  2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

## 2.5 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Allen-Bradley/Rockwell Automation.
  - 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
  - 3. Eaton Corporation.
  - 4. General Electric Company; GE Consumer & Industrial - Electrical Distribution; Total Lighting Control.
  - 5. Square D; a brand of Schneider Electric.
- B. Description: Electrically operated and mechanically held, complying with NEMA ICS 2 and UL 508.
  - 1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
  - 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
  - 3. Enclosure: Comply with NEMA 250.
  - 4. Provide with control and pilot devices as indicated on Drawings.

## 2.6 EMERGENCY SHUNT RELAY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings.
- C. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
  - 1. Coil Rating: As required based on circuiting.

## 2.7 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section 26 76 26 "Wiring Devices."
- 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 26 76 26 "Wiring Devices."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section 26 76 26 "Wiring Devices."

## PART 3 - EXECUTION

### 3.1 SENSOR INSTALLATION

- A. 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.
- B. When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

### 3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

### 3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section 26 76 26 "Wiring Devices." Minimum conduit size shall be 3/4 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section 26 05 53 "Electrical Identification."
  - 1. Identify controlled circuits in lighting contactors.
  - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.



Project Name  
Project Number

Deliverable  
Issue Date

2. Operational Test: Verify operation of each lighting control device and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

**END OF SECTION**

**SECTION 26 22 00**  
**LOW-VOLTAGE TRANSFORMERS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
  - 1. Distribution transformers.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For each product indicated.
- B. Shop Drawings: Indicate dimensions and weights.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

**1.5 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 IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. General Electric Company.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D; Schneider Electric.

4. PQI.
5. Powersmiths.

## 2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
  1. Internal Coil Connections: Brazed or pressure type.
  2. Coil Material: Copper.
- D. Covers: Hinged service access

## 2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section 26 05 29 "Hangars and Supports."
- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, NEMA 250, Type 2.
  1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- E. Enclosure: Ventilated, NEMA 250, Type 3R.
  1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- F. Transformer Enclosure Finish: Comply with NEMA 250.
  1. Finish Color: Gray.
- G. Taps for Transformers Smaller Than 3 kVA: 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: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- K. Energy Efficiency for Transformers Rated 15 kVA and Larger:
  1. Complying with NEMA TP 1, Class 1 efficiency levels.

2. Tested according to NEMA TP 2.
- L. 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.
  2. Indicate value of K-factor on transformer nameplate.
- M. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
- N. Wall Brackets: Manufacturer's standard brackets.

## 2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated plastic or metal nameplate. Nameplates are specified in Division 26 Section 26 05 53 "Identification for Electrical Systems."

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install wall-mounting transformers level and plumb as per SRP standard detail.
- B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions and SRP standard detail.

### 3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. 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. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
    - a. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
    - b. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
    - c. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

### 3.3 ADJUSTING

- A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
- C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

**END OF SECTION**

## **SECTION 26 24 13**

### **SWITCHBOARDS**

#### **PART 1 - GENERAL**

##### **1.1 SUMMARY**

- A. Section includes:
  - 1. Service and distribution switchboards rated 600 V and less.
  - 2. Transient voltage suppression devices.
  - 3. Disconnecting and overcurrent protective devices.
  - 4. Instrumentation.
  - 5. Control power.
  - 6. Accessory components and features.
  - 7. Identification.

##### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
  - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Wiring Diagrams: Power, signal, and control wiring.

##### **1.3 INFORMATIONAL SUBMITTALS**

- A. Field quality-control test reports.

##### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

##### **1.5 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 NEMA PB 2, "Deadfront Distribution Switchboards."
- C. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

### 2.2 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following below. Manufacturer must be approved by SRP prior to purchase and will be determined partially based on building's existing equipment manufacturer.
  - 1. General Electric Co.; Electrical Distribution & Protection Div.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D.
- B. Front-Connected, Front-Accessible Switchgear with rack out main and feeder circuit breakers:
- C. Nominal System Voltage: 277/480V.
- D. Main-Bus Continuous: Refer to drawings.
- E. Enclosure: Steel, NEMA 250, Types 1 and 3R, refer to drawings.
- F. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- G. Barriers: Between adjacent switchboard sections.
- H. Utility Metering Compartment: Fabricated compartment and section complying with Owner requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- I. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- J. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- K. 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.
- L. Buses and Connections: Three phase, four wire, unless otherwise indicated. Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.
1. Ground Bus: 1/4-by-2-inch minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure 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.
  2. Contact Surfaces of Buses: Silver plated.
  3. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
  4. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
  5. Neutral Buses: 50 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.
- M. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

### 2.3 TRANSIENT VOLTAGE SUPPRESSION DEVICES

- A. IEEE C62.41, integrally mounted, plug-in-style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
- B. Minimum single-impulse current rating shall be as follows:
1. Line to Neutral: 100,000 A.
  2. Line to Ground: 100,000 A.
  3. Neutral to Ground: 50,000 A.
- C. Protection modes shall be as follows:
1. Line to neutral.
  2. Line to ground.
  3. Neutral to ground.
- D. EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.
- E. Maximum Category C combination wave clamping voltage shall not exceed 1000 V, line to neutral and line to ground on 277/480 V systems.



- F. Maximum UL 1449 clamping levels shall not exceed 800 V, line to neutral and line to ground on 277/480 V systems.
- G. Withstand Capabilities: 3000 Category C surges with less than 5 percent change in clamping voltage.
- H. Accessories:
  - 1. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
  - 2. Audible alarm activated on failure of any surge diversion module.
  - 3. Six-digit transient-counter set to total transient surges that deviate from the sine-wave envelope by more than 125 V.

## 2.4 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 3, 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-unit circuit breakers shall have RMS sensing, field-replaceable rating plug, 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 30-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles
  - 1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
  - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
  - 3. Ground-Fault Protection: Integral to circuit breakers with adjustable pickup and time-delay settings, and ground-fault indicator.

- C. Insulated-Case Circuit Breaker: Fully rated, encased-power circuit breaker with interrupting capacity rating to meet available fault current.
  - 1. Drawout circuit-breaker mounting.
  - 2. Two-step, stored-energy closing.
  - 3. Microprocessor-based trip units with interchangeable rating plug, LED trip indicators, and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments with  $I^2t$  response.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
- D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- E. Fuses are specified in Division 26 Section 26 28 13 "Fuses."

## 2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Furnish one portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Furnish overhead circuit-breaker lifting device, mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

## 2.6 IDENTIFICATION

- A. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- B. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1 and NECA 40.

- B. Install and anchor switchboards level on concrete bases, 4-inch nominal thickness. Concrete base is specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges.

### 3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 05 53 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

### 3.3 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

**END OF SECTION**

## SECTION 26 24 16

### PANELBOARDS

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. This Section includes all panelboards.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, overcurrent protective device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - a. Enclosure types and details for types other than NEMA 250, Type 1.
    - b. Bus configuration, current, and voltage ratings.
    - c. Short-circuit current rating of panelboards and overcurrent protective devices.
    - d. UL listing for series rating of installed devices.
    - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 2. Wiring Diagrams: Power, signal, and control wiring.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

##### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

##### 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended use.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

1.6 WARRANTY

- A. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: Flush- and surface-mounted cabinets.
1. Rated for environmental conditions at installed location.
    - a. Outdoor Locations: NEMA 250, Type 3R.
    - b. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
    - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
    - d. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
  2. Front: Secured to box with concealed side hinges. 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.
    - a. For Siemens and Square D products, requires "door in door" panel option.
    - b. For GE products, this requires "door in door" panel option.
  4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- B. Incoming Mains Location: Top and bottom.
- C. Phase and Ground Buses: Hard-drawn copper, 98 percent conductivity.
- D. Conductor Connectors: Suitable for use with conductor material.
1. Ground Lugs and Bus Configured Terminators: Compression type.
  2. Material: Hard-drawn copper, 98 percent conductivity.
  3. Main and Neutral Lugs: Compression type.
  4. Ground Lugs and Bus Configured Terminators: Compression type.
  5. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
  6. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- E. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- F. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- G. Panelboard Short-Circuit Rating:
1. UL label indicating series-connected rating with integral or remote upstream overcurrent protective devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.

2. Fully rated to interrupt symmetrical short-circuit current available at terminals.

## 2.2 DISTRIBUTION, LIGHTING, AND APPLIANCE PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following below. Manufacturer must be approved by SRP prior to purchase and will be determined partially based on building's existing equipment manufacturer.
1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  2. Siemens Energy & Automation, Inc.
  3. Square D; a brand of Schneider Electric.

## 2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following below. Manufacturer must be approved by SRP prior to purchase and will be determined partially based on building's existing equipment manufacturer.
1. Siemens Energy & Automation, Inc.
  2. Square D; a brand of Schneider Electric.
  3. General Electric
- B. Molded-Case Circuit Breaker: UL 489, with series-connected rating or interrupting capacity as shown on the design 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.
  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 Drawings.
  - f. Shunt Trip: 120 or 24 -V trip coil energized from separate circuit, set to trip at 55 or 75 percent of rated voltage.
  - g. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
  - h. 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 are specified in Division 26 Section 26 28 13 "Fuses."

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Mount top of trim 90 inches above finished floor, unless otherwise indicated.
- C. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- D. Install overcurrent protective devices and controllers.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- E. Install filler plates in unused spaces.
- F. Identify field-installed conductors and components. Bundle and wrap with tie wires, mark with identification as specified in Division 26 Section 26 05 53 "Identification for Electrical Systems."
- G. Panelboard Nameplates: Label as specified in Division 26 Section 26 05 53 "Identification for Electrical Systems."
- H. Create a printed panel schedule (directory) to indicate installed circuit loads and spares. Obtain approval before installing. Handwritten schedules are not acceptable.
- I. Ground equipment according to Division 26 Section 26 05 26 "Grounding and Bonding."

- J. Connect wiring according to Division 26 Section 26 05 19 "Low-Voltage Conductors and Cables."

### 3.2 QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Panelboards will be considered defective if they do not pass tests and inspections.

**END OF SECTION**



**SECTION 26 24 19**  
**MOTOR CONTROL CENTERS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This Section Includes:
  - 1. Motor-control centers for use on ac circuits rated 600 V and less.

**1.2 SUBMITTALS**

- A. Product Data: For each type of controller and each type of motor-control center.
- B. Shop Drawings: For each motor-control center.
  - 1. Include wiring diagrams.
- C. Qualification Data: For manufacturer and testing agency.
- D. Field quality-control test reports.
- E. Operation and maintenance data.
- F. Load-current and overload-relay heater list.
- G. Load-current and list of settings of adjustable overload relays.

**1.3 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100.
- B. Comply with NFPA 70.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

**1.4 COORDINATION**

- A. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

- B. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. General Electric Company; GE Industrial Systems.
  2. Siemens/Furnas Controls.
  3. Square D.

### 2.2 MOTOR- CONTROL CENTERS

- A. Wiring: NEMA ICS 3, Class I or Class II.
- B. Enclosures: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
  1. Outdoor Locations: NEMA 250, Type 3R.
  2. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
  3. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center; 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.
  4. Wiring Spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.
- C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.

### 2.3 BUSES

- A. Material: Plated hard-drawn copper, 98 percent conductivity.
- B. Ampacity Ratings: As indicated for horizontal and vertical main buses.
- C. Neutral Buses: Full size.
- D. Equipment Ground Bus: Noninsulated, horizontal configuration; adequate for equipment ground conductors; bonded to enclosure.

- E. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.
- F. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

## 2.4 FUNCTIONAL FEATURES

- A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center.
- B. Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.
  - 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. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.
  - 3. Equip units in Type B and Type C motor-control centers with pull-apart terminal strips or drawout terminal boards for external control connections.
  - 4. Controller Disconnecting Means: Factory-assembled combination disconnect and controller.
    - a. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.
    - b. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
    - c. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- C. Overcurrent Protective Devices: Individual 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. Spaces and Blank Compartments: Fully bused and equipped, ready for insertion of drawout units.
- E. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated "spare."

## 2.5 ACROSS THE LINE CONTROLLERS

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with toggle action and overload element.
- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
3. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 10 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

## 2.6 MULTISPEED CONTROLLERS

- A. Multispeed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
1. Compelling relay to ensure that motor will start only at low speed.
  2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
  3. Decelerating relay to ensure automatically timed deceleration through each speed.

## 2.7 FEEDER OVERCURRENT PROTECTIONS

- A. 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.
1. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  2. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with 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<sup>2</sup>t response.
  3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  4. 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.
  5. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
  6. Molded-Case Switch: Molded-case circuit breaker without trip units.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
  2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
  3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  4. Communication Capability: Circuit-breaker-mounted, Universal-mounted, or Integral communication module with functions and features compatible with power monitoring and control system.
  5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 or 75 percent of rated voltage.
  6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional or with field-adjustable 0.1- to 0.6-second time delay.
  7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts; "b" contacts operate in reverse of circuit- breaker contacts.
  8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
- C. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate fuses with lockable handle.

## 2.8 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. 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.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Meters:
1. Ammeter: Output current, with current sensors rated to suit application.
  2. Voltmeter: Output voltage.
  3. Frequency Meter: Output frequency.
- F. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.
- G. Spare-Fuse Cabinet: Identified and compartmented steel box.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

### 3.2 INSTALLATION

- A. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor- control center mounting surface.
- B. Install motor-control centers on concrete bases.
- C. Controller Fuses: Install fuses in each fusible switch. Comply with Section 26 28 13 "Fuses".

### 3.3 IDENTIFICATION

- A. Identify motor-control center, motor-control center components, and control wiring according to Division 26 Section 26 05 53 "Identification for Electrical Systems."
- B. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

### 3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between motor-control devices according to Division 26 Section 26 05 19 "Low Voltage Conductors and Cables." Bundle, train, and support wiring in enclosures.
- B. Connect hand-off-automatic switch and other automatic-control devices where applicable.
  - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
  - 2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

### 3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.

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- B. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection, except for optional tests, stated in NETA ATS "Motor Control Centers." Certify compliance with test parameters.
  2. Correct malfunctioning units and retest to demonstrate compliance; otherwise, replace with new units and retest.

**END OF SECTION**

**SECTION 26 26 00**  
**POWER DISTRIBUTION UNITS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This Section includes freestanding, prepackaged, power distribution units for transforming, conditioning, and distributing electrical power.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For power distribution units. Include system description, ratings, capacities, and performance characteristics.
- B. Shop Drawings: Include dimensioned plans, sections, and elevations. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Manufacturer Seismic Qualification Certification: Submit certification that power distribution units, accessories, and components will withstand seismic forces defined in Drawings.
- B. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

**1.5 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.

**1.6 PROJECT CONDITIONS**

- A. Environmental Conditions:
  - 1. Storage Temperature Range: Minus 67 to plus 185 deg F (Minus 55 to plus 85 deg C).
  - 2. Operating Temperature Range: 32 to 104 deg F (0 to 40 deg C).



3. Relative Humidity Range: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 3600 feet (1100 m) above sea level.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. 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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or Owner approved equal:
  1. Liebert Corporation; a division of Emerson.
  2. Power Distribution, Inc.
  3. Square D; Schneider Electric.
  4. Toshiba.

### 2.2 MANUFACTURED UNITS

- A. Description: Integrated and coordinated assembly of power-line-conditioning and distribution components packaged in a single cabinet or modular assembly of cabinets. Include the following components:
  1. Input-power, circuit-breaker section.
  2. Isolation transformer.
  3. TVSS system.
  4. Output feeder breakers.
  5. Alarm, monitoring, and control system.
- B. Unit Capacity Rating: Unit shall carry indicated rms kilovolt-ampere load continuously without exceeding rated insulation temperature for the following input voltage and load current:
  1. Input Voltage: Within rated input-voltage tolerance band of unit.
  2. Load Current: Minimum of 3.0 crest factor and 85 percent total harmonic distortion.

### 2.3 INPUT-POWER, CIRCUIT-BREAKER SECTION

- A. Description: 3-pole, shunt-tripped, thermal-magnetic-type circuit breaker, rated for indicated interrupting capacity and 125 percent of input current of unit at 100 percent rated load.

### 2.4 ISOLATION TRANSFORMER SECTION

- A. Description: Dry-type, electrostatically shielded, three-phase, common-core, convection-air-cooled isolation transformer.

1. Comply with UL 1561 including requirements for nonsinusoidal load-current-handling capability defined by designated K-factor.
2. Cores: Grain-oriented, non-aging silicon steel, one leg per phase.
3. Coil Material and Insulation: Copper windings with a 220 deg C insulation class.
4. Temperature Rise: Designed for 150 deg C rise above 40 deg C ambient.
5. Output Impedance: 3.5 plus or minus 0.5 percent.
6. Regulation: 2 to 4 percent maximum, at full-resistive load; 5 percent maximum, at rated nonlinear load.
7. Taps: 6 full-capacity compensation taps at 2.5 percent increments; 2 above and 4 below nominal voltage.
8. Full-Load Efficiency: Minimum 96 percent at rated nonlinear load.
9. Magnetic-Field Strength External to Transformer Enclosure: Less than 0.1 Gauss at 450 mm.
10. Electrostatic Shield.
11. Neutral Rating: 1.732 times the system full-load ampere rating.

## 2.5 TVSS SYSTEM

- A. Description: Integrated TVSS system complying with Section 26 43 13 "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits," to protect unit panelboard, and having the following features:
1. Disconnect Device: Manual, three-pole, fused disconnect switch. Fuses are rated at 200-kA interrupting capacity.

## 2.6 POWER DISTRIBUTION UNIT CONTROLS

- A. Include the following control features:
1. Emergency, power-off switch integral with power distribution unit.
  2. Emergency, power-off input terminals for connection to remote power-off switch.
  3. Over-under alarm shutdown with automatic unit disconnection for the following alarm conditions:
    - a. High temperature.
    - b. High and low input or output voltage.
    - c. Phase loss.
    - d. Ground fault.
    - e. Reverse phase rotation.
  4. Ground-fault protection with automatic system shutdown.
  5. Alarm Contacts: Electrically isolated, Form C (one normally open and one normally closed), summary alarm; contact set shall change state if any monitored function goes into alarm mode.
  6. Remote Power-Off Control: Control circuit with connection to shunt trip of power distribution unit main power circuit breaker and terminals for connection to one or more remote power-off, push-button stations.

## 2.7 MONITORING, STATUS, AND ALARM ANNUNCIATION

- A. Description: Microprocessor-based monitoring, status, and alarm annunciation panel mounted flush in front of power distribution unit to provide status display and failure-indicating interface for the following:
1. Power Monitoring:
    - a. Input Voltage: Line to line, rms.
    - b. Output Voltage: Line to line, rms.
    - c. Output Voltage: Line to neutral, rms.
    - d. Output current.
  2. Status Indication: Unit on.
  3. Alarm Annunciation:
    - a. High temperature.
    - b. High and low input voltage.
    - c. High and low output voltage.
    - d. Phase loss.
    - e. Ground fault.
    - f. Frequency.
    - g. Phase rotation.
    - h. TVSS module failure.
  4. Audible Alarm and Silencing Switch: Silencing switch shall silence audible alarm but leave visual indication active until failure or other alarm conditions are corrected.

## 2.8 SOUND LEVEL

- A. General: Fully assembled products comply with minimum sound-level requirements in NEMA ST 20 for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Arrange power distribution units to provide adequate access to equipment and circulation of cooling air.
- B. Anchor or restrain floor-mounting power distribution units according to manufacturer's written instructions.
- C. Identify equipment and install warning signs according to Section 26 05 53 "Identification for Electrical Systems."

### 3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification for circuit breakers, molded case; and for transformers, dry type, air cooled, low voltage, small. Certify compliance with test parameters.
2. Perform functional tests of power distribution units throughout their operating ranges. Test each monitoring, status, and alarm function.
3. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of conductor and bus connections.
  - a. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
  - b. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
  - c. Prepare a certified report identifying connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3.3 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- B. Adjust power distribution units to provide optimum voltage to equipment served throughout normal operating cycle of loads served.

**END OF SECTION**

**SECTION 26 27 13**  
**ELECTRICITY METERING**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes equipment for electricity metering by utility company.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Dimensioned plans and sections or elevation layouts and wiring diagrams.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
  - 1. Hard copies of manufacturer's operating specifications and PDF files of the hard-copy Submittal.

**1.5 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.

**PART 2 - PRODUCTS**

**2.1 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.

- D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

### PART 3 - EXECUTION

#### 3.1 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.
- C. Install modular meter center according to NECA 400 switchboard installation requirements.
- D. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

**END OF SECTION**

## **SECTION 26 27 26**

### **WIRING DEVICES**

#### **PART 1 - GENERAL**

##### **1.1 SUMMARY**

- A. Section includes:
  - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
  - 2. Weather-resistant receptacles.
  - 3. Snap switches and wall-box dimmers.
    - a. Wall-switch occupancy sensors.
  - 4. Communications outlets.

##### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples for Verification: One for each type of device and wall plate specified, in each color specified.

##### **1.3 INFORMATIONAL SUBMITTALS**

- A. Field quality control reports.

##### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For wiring devices to include in manufacturers' packing label warnings and instruction manuals that include labeling conditions.

##### **1.5 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.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
  2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
  3. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
  4. Leviton Mfg. Company Inc. (Leviton).

### 2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper; 5351 (single), CR5362 (duplex).
    - b. Hubbell; HBL5351 (single), HBL5352 (duplex).
    - c. Pass & Seymour; 5361 (single), 5362 (duplex).
    - d. Leviton; 5891 (single), 5352 (duplex).

### 2.3 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. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper; VGF20.
    - b. Pass & Seymour; 2095.
    - c. Hubbell; GFR5352L.
    - d. Leviton; 7590.

### 2.4 TOGGLE (SNAP) SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper;
    - b. Hubbell;
    - c. Pass & Seymour;
    - d. Leviton.



- C. Pilot Light Switches, 20 A:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper;
    - b. Hubbell;
    - c. Pass & Seymour;
    - d. Leviton;
  - 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
  
- D. Key-Operated Switches, 120/277 V, 20 A:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Pass & Seymour;
    - b. Leviton;
  - 2. 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.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper.
    - b. Hubbell.
    - c. Leviton.
  
- F. Key-Operated, 120/277 V, 20 A; single pole, with factory-supplied key in lieu of switch handle.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper;
    - b. Hubbell;
    - c. Pass & Seymour;
    - d. Leviton;

## 2.5 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 type; with single-pole or three-way switching. Comply with UL 1472.
- C. LED 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 10 percent of full brightness.

## 2.6 OCCUPANCY SENSORS

- A. Wall-Switch Sensors:
  - 1. Products: Refer to schedules on Drawings.
  - 2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

## 2.7 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: Smooth, high-impact thermoplastic or 0.035-inch-thick, satin-finished stainless steel.
  - 3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
  - 4. Material for Damp Locations: Thermoplastic 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 while-in-use type with lockable cover.

## 2.8 FINISHES

- A. Color:
  - 1. Wiring Devices Connected to Normal Power System: Ivory or as selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
  - 2. Wiring Devices Connected to Emergency Power System: Red.
  - 3. TVSS Devices: Blue.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
  - 1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
  - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  - 4. Install wiring devices after wall preparation, including painting, is complete.
- C. Conductors:
  - 1. All conductors shall be stranded, no solid conductors are permitted.
  - 2. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
  - 3. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

4. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
  5. Existing Conductors:
    - a. Cut back and pigtail, or replace damaged conductors.
    - b. Straighten conductors that remain and remove corrosion and foreign matter.
    - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
1. Replace devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
  2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
  4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
  5. When there is a choice, use side wiring with binding-head screw terminals. Wrap conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
  6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
  7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
  8. Tighten unused terminal screws on the device.
  9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Receptacles to be mounted horizontally only when indicated.
  2. Ground pin orientation (to the right or the left) for horizontally mounted receptacles shall be per manufacturer's recommendations or installation instructions.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Dimmers:
1. Install dimmers within terms of their listing.
  2. Verify that dimmers used for fan speed control are listed for that application.
  3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and grounding terminal mounted per manufacturer installation instructions. Group adjacent switches under single, multigang wall plates.

### 3.2 IDENTIFICATION

- A. Comply with Section 26 05 53 " Identification for Electrical Systems."
  - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

### 3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
  - 1. Test Instruments: Use instruments that comply with UL 1436.
  - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- B. Tests for Convenience Receptacles:
  - 1. Line Voltage: Acceptable range is 105 to 132 V.
  - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
  - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
  - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
  - 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

**END OF SECTION**

## SECTION 26 28 13

### FUSES

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes:
  - 1. Cartridge fuses rated 600 V and less for use in switches, switchboards, controllers and motor-control centers.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each fuse type indicated.

##### 1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

##### 1.4 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 NEMA FU 1.
- C. Comply with NFPA 70.

#### PART 2 - PRODUCTS

##### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Bussman, Inc.
  - 2. Littelfuse, Inc.
  - 3. Edison Fuse, Inc.
  - 4. Ferraz Shawmut, Inc.

## 2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

## PART 3 - EXECUTION

### 3.1 FUSE APPLICATIONS

- A. Service Entrance: Class L, time delay; RK1, time delay; J, time delay.
- B. Feeders: Class L, time delay; RK1, time delay; J, time delay; RK5, time delay.
- C. Motor Branch Circuits: Class RK5, time delay.
- D. Other Branch Circuits: Class RK5, time delay; J, time delay.

### 3.2 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

### 3.3 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

**END OF SECTION**

## SECTION 26 28 16

### ENCLOSED SWITCHES AND CIRCUIT BREAKERS

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes the following individually mounted, enclosed switches and circuit breakers:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Molded-case circuit breakers.
  - 4. Enclosures.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

##### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

##### 1.5 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.

#### PART 2 - PRODUCTS

##### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:

### ENCLOSED SWITCHES AND CIRCUIT BREAKERS

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1. General Electric Co.; Electrical Distribution & Control Division.
2. Siemens Energy & Automation, Inc.
3. Square D/Group Schneider.

## 2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Fusible Switch, 1200A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- B. Nonfusible Switch, 1200A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. 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; and labeled for copper and aluminum neutral conductors.
  3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

## 2.3 MOLDED CASE CIRCUIT BREAKERS AND SWITCHES

- A. Molded-Case Circuit Breaker: NEMA AB 1, 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. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
  4. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories:
  1. Standard frame sizes, trip ratings, and number of poles.
  2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
  3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
  4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.



## 2.4 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
  - 1. Outdoor Locations: NEMA 250, Type 3R.
  - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
  - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- C. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section 26 05 33, "Identification for Electrical Systems".

### 3.2 FIELD QUALITY CONTROL

- A. Prepare for acceptance testing as follows:
  - 1. Inspect mechanical and electrical connections.
  - 2. Verify switch and relay type and labeling verification.
  - 3. Verify rating of installed fuses.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

**END OF SECTION**

**SECTION 26 29 13**  
**ENCLOSED CONTROLLERS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes ac, enclosed controllers rated 600 V and less, of the following types:
  - 1. Across-the-line, manual and magnetic controllers.
  - 2. Multispeed controllers.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of enclosed controller.
- B. Shop Drawings: For each enclosed controller.
  - 1. Include wiring diagrams.
- C. Load-current and overload-relay heater list.
- D. Load-current and list of settings of adjustable overload relays.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Field quality control test reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

**1.5 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100.
- B. Comply with NFPA 70.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

## 1.6 COORDINATION

- A. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- B. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
  - 2. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
  - 3. Siemens/Furnas Controls.

### 2.2 ACROSS THE LINE ENCLOSED CONTROLLER

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."
  - 1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.
- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
  - 1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
  - 2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
  - 3. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

- C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.
  - 1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.
  - 2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
  - 3. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

## 2.3 MULTISPEED ENCLOSED CONTROLLERS

- A. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
  - 1. Compelling relay to ensure that motor will start only at low speed.
  - 2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
  - 3. Decelerating relay to ensure automatically timed deceleration through each speed.

## 2.4 ENCLOSURES

- A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated.
  - 1. Outdoor Locations: NEMA 250, Type 3R.

## 2.5 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

## PART 3 - EXECUTION

### 3.1 APPLICATIONS

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

### 3.2 INSTALLATION

- A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks.
- B. Install freestanding equipment on concrete bases.
- C. Comply with mounting and anchoring requirements specified in Division 26 Section 26 05 29 "Hangers and Supports."
- D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section 26 28 13 "Fuses."

### 3.3 IDENTIFICATION

- A. Identify enclosed controller, components, and control wiring according to Division 26 Section 26 05 53 "Identification for Electrical Systems."

### 3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26 Section 26 05 19 "Low-Voltage Conductors and Cables." Bundle, train, and support wiring in enclosures.
- B. Connect hand-off-automatic switch and other automatic-control devices where applicable.
  - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
  - 2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

### 3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.

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- B. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, "Motor Control - Motor Starters." Certify compliance with test parameters.
  2. Correct malfunctioning units and retest to demonstrate compliance; otherwise, replace with new units and retest.

**END OF SECTION**

ENCLOSED CONTROLLERS  
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*Last Updated:*

*April 2022*

**SECTION 26 32 31**  
**ENGINE GENERATORS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes packaged engine-generator sets for standby power supply with the following features:
  - 1. Diesel engine.
  - 2. Unit-mounted cooling system.
  - 3. Unit-mounted control and monitoring.
  - 4. Outdoor enclosure.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of packaged engine generator and accessory indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Source quality-control test reports.
- B. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.
- B. Warranty: Special warranty specified in this Section.

**1.5 QUALITY ASSURANCE**

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

- C. 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.
- D. Comply with ASME B15.1.
- E. Comply with NFPA 37.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110 requirements for Level 2 emergency power supply system.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

#### 1.6 FIELD CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: 5 to 40 deg C.
  - 2. Relative Humidity: 0 to 95 percent.
  - 3. Altitude: 1300 feet (for installations in Phoenix MSA).

#### 1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Two years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Caterpillar; Engine Div.
  - 2. Generac Power Systems.
  - 3. Onan/Cummins Power Generation; Industrial Business Group.



## 2.2 ENGINE GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
- C. Capacities and Characteristics:
  - 1. Power Output Ratings: Nominal ratings as indicated.
  - 2. Output Connections: Three-phase, four wire.
  - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
  - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
  - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
  - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
  - 4. Steady-State Frequency Stability: When system is operating at constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
  - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  - 7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
  - 8. Start Time: Comply with NFPA 110, Type 10, system requirements.

## 2.3 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.
- D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
  3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
  2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  2. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz.
  2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 87 dBA or less.
- J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
  2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  3. Cranking Cycle: As required by NFPA 110 for Level 2.
  4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least twice without recharging.

5. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
  - a. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.

## 2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
  1. Tank level indicator.
  2. Capacity: Fuel for 24 hours' continuous operation at 100 percent rated power output.
  3. Vandal-resistant fill cap.
  4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

## 2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 2 system, and the following:
  1. AC voltmeter.
  2. AC ammeter.
  3. AC frequency meter.
  4. DC voltmeter (alternator battery charging).
  5. Engine-coolant temperature gage.
  6. Engine lubricating-oil pressure gage.

7. Running-time meter.
  8. Ammeter-voltmeter, phase-selector switch(es).
  9. Generator-voltage adjusting rheostat.
  10. Fuel tank derangement alarm.
  11. Fuel tank high-level shutdown of fuel supply alarm.
  12. Generator overload.
- E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- F. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 2 systems. Include necessary contacts and terminals in control and monitoring panel.
1. Overcrank shutdown.
  2. Coolant low-temperature alarm.
  3. Control switch not in auto position.
  4. Battery-charger malfunction alarm.
  5. Battery low-voltage alarm.
- G. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

## 2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
1. Tripping Characteristic: Designed specifically for generator protection.
  2. Trip Rating: Matched to generator rating.
  3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
  4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

## 2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
  - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

## 2.8 OUTDOOR GENERATOR SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
  - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
  - 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
- C. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
  - 1. AC lighting system and connection point for operation when remote source is available.
  - 2. DC lighting system for operation when remote source and generator are both unavailable.
- D. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

## 2.9 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
  - 1. Material: Standard neoprene.
  - 2. Durometer Rating: 60.
  - 3. Number of Layers: Four.
  
- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
  - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  - 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
  - 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
  - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

## 2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
  - 2. Report factory test results within 10 days of completion of test.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
  
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

- C. Install packaged engine generator with elastomeric isolator pads on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section 26 05 29 "Hangers and Supports."
- D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section 23 21 13 "Hydronic Piping."
  - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section 23 21 13 "Hydronic Piping."
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
- F. Piping installation requirements are specified in Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- G. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- H. Connect engine exhaust pipe to engine with flexible connector.
- I. Ground equipment according to Division 26 Section 26 05 26 "Grounding and Bonding."
- J. Connect wiring according to Division 26 Section 26 05 19 "Low-Voltage Conductors and Cables."
- K. Identify system components according to Division 23 Section 23 05 53 "Identification for HVAC Piping and Equipment" and Division 26 Section 26 05 53 "Identification for Electrical Systems."

### 3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
  - 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. Provide manufacturer's Installation checklist and Startup checklist completed and signed by the service representative, prior to beginning the (Functional Performance Test) Commissioning.
  - 2. Conduct Commissioning of the generator set in accordance with Division 26 Section 26 32 35 "Standby Generator Testing and Commissioning".
- B. Tests and Inspections:

1. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  2. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  3. Noise Level Tests: Measure level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, as required in Paragraph 2.3, I and ensure the noise complies with required values.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- 3.3 TRAINING
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section 01 79 00 "Demonstration and Training."

**END OF SECTION**



## SECTION 26 32 35

### STANDBY GENERATOR TESTING AND COMMISSIONING

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Standby generators.
  - 2. Automatic Transfer Switches (ATS).
  - 3. System start-up services.
  - 4. Battery charging system testing.
  - 5. Load bank testing.
  - 6. Integral system testing.
  - 7. System demonstration.
- B. Equipment, including load banks, measuring instruments, cables, connectors, etc. required for the site testing of the complete generator installation shall be provided by the generator manufacturer's factory authorized firm. Installer shall assist and coordinate with the generator manufacturer's factory authorized firm in the administration and performance of the site testing.
- C. Related Requirements:
  - 1. Division 26 Section 26 33 54 "Static UPS Testing and Commissioning."

##### 1.2 INFORMATIONAL SUBMITTALS

- A. Factory test reports.
- B. Field test reports and other documentation including a description of test procedures and inspections, with results listed for each test performed, in a type-written format. Include results of tests, inspections, and retests.
- C. Infrared scanning reports with pictures printed in a final report with deficiencies and actions taken to rectify.

##### 1.3 QUALITY ASSURANCE

- A. Provide a list of testing equipment with make and model numbers. Test Equipment shall have current calibration validation.

## PART 2 - PRODUCTS

- A. (Not Used)

## PART 3 - EXECUTION

### 3.1 SYSTEM START UP

- A. Perform tests and inspections and prepare test reports.
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.
  2. Perform generator testing, ATS testing and integral system testing including both generators and ATS.
- B. Visual and Mechanical Inspections:
1. Compare equipment nameplate data with drawings and specifications.
  2. Inspect physical and mechanical condition.
  3. Inspect anchorage, alignment and grounding.
  4. Verify unit is clean.
  5. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding parts (ATS).
  6. Verify ATS warnings are attached and visible.
  7. Verify tightness of control connections.
- C. Generator Electrical and Mechanical Tests:
1. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.
    - a. Machines larger than 200 horsepower (150kW): Test duration shall be ten minutes minimum. Calculate the polarization index.
    - b. Machines 200 horsepower (150kW) or less: Test duration shall be one minute minimum. Calculate the dielectric-absorption ratio.
  2. Test protective relays and main circuit breakers.
  3. System Integrity Tests: Methodically verify proper installation, anchorage, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  4. Test phase rotation, phasing and synchronized operation as required by the application.
  5. Functionally test engine shutdown for low oil pressure, over-temperature over-speed, and other protective features as applicable.
  6. Perform vibration test for each main bearing cap.
  7. Verify correct functioning of the governor and regulator.

8. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  9. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of connectors. Perform a battery system integrity load test and a capacity load test.
    - c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.
  10. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  11. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
  12. Exhaust Emissions Test: Comply with applicable government test criteria.
  13. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  14. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  15. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at on the property line, and compare measured levels with required values.
- D. ATS Electrical and Mechanical Tests:
1. Inspect bolted electrical connections for high resistance using one of the following methods:
    - a. Use of low-resistance ohmmeter.
    - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
    - c. Perform thermographic survey.
  2. Perform manual transfer operation.
  3. Verify positive mechanical interlocking between normal and alternate sources.
  4. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
  5. Perform a contact/pole-resistance test.
  6. Verify settings and operation of control devices.

7. Calibrate and set relays and timers.
  8. Verify phase rotation, phasing, and synchronized operation as required by the application.
  9. Perform automatic transfer test:
    - a. Simulate loss of normal power.
    - b. Return to normal power.
    - c. Simulate loss of emergency power.
    - d. Simulate forms of single-phase conditions.
  10. Verify correct operation and timing of the following functions:
    - a. Normal source voltage-sensing relays.
    - b. Engine start sequence.
    - c. Time delay upon transfer.
    - d. Alternate source voltage-sensing relays.
    - e. Automatic transfer operation.
    - f. Interlocks and limit switch function.
    - g. Time delay and retransfer upon normal power restoration.
    - h. Engine cool down and shutdown feature.
- E. ATS Test Values:
1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  2. Bolt torque levels shall be in accordance with manufacturer's published data.
  3. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
  4. Control devices shall operate in accordance with manufacturer's published data.
  5. Phase rotation, phasing, and synchronization shall be in accordance with system design specifications.
  6. Automatic transfers shall operate in accordance with manufacturer's design.
  7. Operation and timing shall be in accordance with manufacturer's and system design requirements.
- F. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- I. Report results of tests and inspections in writing. Record adjustable relay and breaker settings and measured insulation resistances, time delays, and other values and

observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

### 3.2 LOAD BANK TESTING

- A. Perform load bank testing as recommended by the manufacturer or as a minimum:
  - 1. Four-hour burn-in test at 100%.
    - a. At end of four-hour burn-in test perform infrared scanning of electrical connections.
  - 2. Perform block loading tests of generator system including:
    - a. 25% for 30 min.
    - b. 50% for 30 min.
    - c. 75% for 60 min.
    - d. 100% for 10 min.
    - e. 75% for 110 min.
- B. Report results of load bank tests in writing. Attach a label or tag to equipment indicating satisfactory completion of load bank tests.

### 3.3 INTEGRAL POWER SYSTEM TEST

- A. An integral power system test shall be performed for projects including the installation of an uninterruptible power system (UPS).
- B. Integral power system test shall be dictated and performed by the UPS system provider.
- C. The generator provider shall provide assistance as required where compatibility issues between the UPS systems and the generator arise including:
  - 1. Compatibility between the UPS system and the generators, i.e. harmonics shall not influence voltage regulation and the UPS input filter shall not affect the generator.
  - 2. Ability of the UPS system to synchronize the generator output.
  - 3. Ability of the UPS system to transfer the load from UPS system to maintenance bypass and back while on generator power.
  - 4. Ability of the UPS to limit battery recharge current while on generator power.

### 3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section 01 79 00 "Demonstration and Training."

**END OF SECTION**

## SECTION 26 33 53

### STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS)

#### PART 1 - GENERAL

##### 1.1 SUMMARY

###### A. Section Includes:

1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
  - a. Surge suppression.
  - b. Rectifier-charger.
  - c. Inverter.
  - d. Static bypass transfer switch.
  - e. Battery and battery disconnect device.
  - f. Battery monitoring.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each UPS component indicated.
- B. Shop Drawings: Detail assemblies of equipment indicating dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
  1. Include wiring diagrams.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.

##### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Warranties.

##### 1.5 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 and for compliance with the following:

1. UL 1778.
2. Suitable for installation in computer rooms according to NFPA 75.

## 1.6 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-Acid 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°F (25°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-Acid 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°F (25°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

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: Two years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Parallel Redundant Operation: The two UPS systems shall be configured to operate in a parallel redundant configuration. Provide controls to ensure proper synchronization.
2. Normal Conditions: Supply the load with ac power flowing from the normal ac power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.

3. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter ac power output to the load without switching or disturbance.
  4. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated ac power to the load without switching or disturbance.
  5. 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.
  6. 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.
  7. If 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.
  8. 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.
  9. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
  10. 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°F (0 to 40°C).
  2. Ambient Temperature for Battery: 41 to 95°F (5 to 35°C).
  3. Relative Humidity: 0 to 95 percent, noncondensing.
  4. Altitude: Sea level to 2000 feet.

## 2.2 PERFORMANCE REQUIREMENTS

- A. The UPS shall perform as specified while supplying rated full-load current, composed of 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 50 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 7 minutes (minimum).
- 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 20 percent from nominal voltage.
- D. Overall UPS Efficiency: Equal to or greater than 95 percent at 100 percent load, 95 percent at 75 percent load, and 95 percent at 50 percent load.
- E. Maximum Acoustical Noise: 73 dB, "A" weighting, emanating from UPS component under condition of normal operation, measured 39 inches (990 mm) 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 single harmonic, for rated full load with THD up to 50 percent, 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 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. EMI Emissions: Comply with FCC Rules and Regulations, and with 47 CFR 15 for Class A equipment.

## 2.3 UPS SYSTEMS

- A. Manufacturers:
  1. Toshiba.
  2. Mitsubishi.
- 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. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- E. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch and static bypass transfer switch. Protect rectifier-charger, inverter, controls, and output components.
  1. Use factory-installed surge suppressors tested according to IEEE C62.41, Category B.
- F. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

### STATIC UNINTERRUPTIBLE POWER SUPPLY

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## 2.4 RECTIFIER CHARGER

- A. 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.
- B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
- C. Rectifier-Charger 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.
- D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

## 2.5 INVERTER

- A. Description: Pulse-width modulated, with sinusoidal output.

## 2.6 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.

## 2.7 BATTERY

- A. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units, and factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.
  - 1. Manufacturers:
    - a. EnerSys, Inc.
    - b. C&D Technologies, Inc.; standby Power Division.

## 2.8 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 overfrequency or underfrequency.
    - 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 overtemperature.
    - 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 overtemperature.
    - w. Inverter overtemperature.
    - x. Static bypass transfer switch overtemperature.

- 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. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.
- E. Manufacturers:
- 1. BTECH Inc.
  - 2. Albercorp.
- F. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
- G. Annunciation of Alarms: At UPS control panel.

## 2.9 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.

## 2.10 SOURCE QUALITY CONTROL

- A. Factory test complete UPS system before shipment. Use simulated battery testing. Include the following:
- 1. Test and demonstration of functions, controls, indicators, sensors, and protective devices.
  - 2. Full-load test.
  - 3. Transient-load response test.

4. Overload test.
  5. Power failure test.
- B. Report test results.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install system components on 4-inch- (100-mm-) high concrete bases. Concrete base construction requirements are specified in Division 26 Section 26 05 29 "Hangers and Supports."
- B. Maintain minimum 36" clearance on (4) four sides and the top to allow for disassembly and servicing.
- C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
- D. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.
- E. Identify components and wiring according to Division 26 Section 26 05 53 "Identification for Electrical Systems."
- F. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

#### 3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust equipment installation including connections [, and to assist in field testing. Report results in writing.
- B. Electrical Tests and Inspections: Perform tests and inspections according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each UPS component:
  1. Inspect interiors of enclosures, including the following:
    - a. Integrity of mechanical and electrical connections.
    - b. Component type and labeling verification.
    - c. Ratings of installed components.
  2. Test manual and automatic operational features and system protective and alarm functions.
- C. Retest: Correct deficiencies and retest until specified requirements are met.

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- D. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

### 3.3 TRAINING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS. Refer to Division 01 Section 01 79 00 "Demonstration and Training."

**END OF SECTION**

## SECTION 26 33 54

### STATIC UPS TESTING AND COMMISSIONING

#### PART 1 - GENERAL

##### 1.1 SUMMARY

A. Section Includes:

1. System start-up services.
2. Battery charging.
3. Load bank testing.
4. Battery load testing.
5. Integral system testing.
6. System demonstration.

- B. Equipment, including load banks, measuring instruments, cables, connectors, etc. required for the site testing of the complete UPS system installation shall be provided by the UPS manufacturer's factory authorized firm. Installer shall assist and coordinate with the UPS manufacturer's factory authorized firm in the administration and performance of the site testing.

##### 1.2 INFORMATIONAL SUBMITTALS

- A. Equipment List: Test equipment with make and model numbers. Test equipment shall have current calibration validation.
- B. Field test reports and other documentation including a description of the test procedures and inspections with results listed for each test performed in a type-written format. Include results of tests, inspections, and retests.
- C. Battery test results including resistance measurements, voltage and temperature readings, specific gravity readings, load values and discharge times and other tests and inspections indicated.
- D. Infrared scanning reports with pictures printed in a final report with deficiencies and actions taken to rectify.

#### PART 2 - PRODUCTS

- A. (Not Used)



## PART 3 - EXECUTION

### 3.1 SITE TESTING

#### A. System Start-Up:

1. After completion of the UPS system installation and battery system certification; the following inspections and test procedures, as a minimum, shall be performed by the UPS manufacturer's Field Engineers.
  - a. Visual Inspection:
    - 1) Compare equipment nameplate data with Drawings and Specifications.
    - 2) Inspect equipment for signs of damage incurred during delivery.
    - 3) Inspect anchorage, alignment, grounding and required clearances.
    - 4) Verify installation per Drawings, including proper termination of cables.
    - 5) Inspect cabinets for foreign objects and remove if present.
    - 6) Verify phase, neutral and ground conductors are properly sized and configured.
    - 7) Verify date code on batteries to ensure batteries have been manufactured within the past 6 months. Return batteries to manufacturer with a date code indicating batteries are older than 6 months.
    - 8) Verify battery racks and cabinets are seismically rated for the geographical location and installed as specified. Verify mounting, anchorage and alignment of battery racks and cabinets.
    - 9) Verify battery support rack and cabinet grounding and clearances.
    - 10) Verify battery systems are clean.
    - 11) Verify and inspect battery spill containment installation.
    - 12) Verify application of oxide inhibitor on battery terminal connections.
  - b. Mechanical Inspection:
    - 1) Check control wiring connections for tightness.
    - 2) Check power wiring connections for tightness.
    - 3) Check terminal screws, nuts, and/or spade lugs for tightness.
    - 4) Verify filters are in place and vents are clear.
    - 5) Verify battery area ventilation is operable.
    - 6) Verify existence of eyewash equipment as required by Drawings.
  - c. Electrical Inspection:
    - 1) Check fuses for continuity.
    - 2) Confirm input and bypass voltage and phase rotation is correct.
    - 3) Verify control transformer connections are correct for voltages being used.
    - 4) Assure connection and voltage of the battery string(s).
    - 5) Verify battery electrolyte levels and measure electrolyte specific gravity and temperature where applicable.
    - 6) Verify alarm indicating lamps and audible devices are operating properly. Record trip points either by simulation or actual fault

#### STATIC UPS TESTING AND COMMISSIONING

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condition. Indicate on documented procedure, which faults, were conducted by which means.

- d. Start-Up Test Procedures:
    - 1) Energize control power.
    - 2) Perform control/logic checks and adjust to meet specification.
    - 3) Verify DC float and equalized voltage levels.
    - 4) Verify DC voltage clamp and overvoltage shutdown levels.
    - 5) Verify battery discharge, low battery warning and low battery shutdown levels.
    - 6) Verify fuse monitor alarms and system shutdown.
    - 7) Verify inverter voltages and regulation circuits.
    - 8) Verify inverter/bypass sync circuits and set overlap time.
    - 9) Perform manual transfer and returns.
    - 10) Simulate utility outage and verify transfer operation to battery source.
    - 11) Verify proper recharge of batteries.
  - e. Provide recording multichannel oscillograph and conduct the following tests to demonstrate operation in conformance with the operating characteristics specified herein:
    - 1) Verify sync to bypass source when within limits including operation from the on-site standby generator system.
    - 2) Verify sync between UPS modules with input source removed alternately from each UPS module, and from both UPS modules, with each UPS module alternately selected as "master" at the ups bus controller panel.
    - 3) Simulate alarms and failure modes. Verify alarm indication, alarm logging, and system response to failure mode with protection of the load.
    - 4) Verify voltage regulation and output waveform while applying and removing step loads of 25%, 50%, 75% and 100% with operation from a normal source and with operation from standby generator source.
    - 5) Verify voltage regulation and output waveform while applying and removing step loads of 25%, 50%, 75% and 100% with operation from the battery source.
    - 6) Verify charger current limit operation.
    - 7) Verify voltage regulation and output waveform while transferring full load to and from the bypass source both manually and automatically.
  - f. Verify proper operation of battery cycle monitor.
2. Pertinent data, including parts replaced and corrective actions taken as a result of the system start-up services, shall be recorded and submitted to the Architect/Engineer, in writing.
- B. Battery Charging:
1. Prior to battery discharge, battery systems shall be tested including internal-cell resistance tests for battery cells, inter-cell connection tests and inter-tier connection tests.

2. Upon completion of the UPS system start-up services, the battery systems shall be given an equalizing charge, if required, as determined by the battery system certification. The battery manufacturer's authorized firm shall include in his base bid the manpower required for qualified personnel to continuously monitor and record pertinent data for the battery systems during the equalize charge period per the selected battery manufacturer's requirements and/or recommendations.
3. After the battery equalizing charge period, the battery systems shall be placed on a float charge per the selected battery manufacturer's recommendations and requirements to stabilize the battery system voltage prior to load bank testing.

C. Load Bank Testing:

1. A 4-hour burn-in, 100% load bank test of the entire UPS system, including UPS modules and battery systems, shall be conducted at the site by the UPS system supplier and the UPS manufacturer's authorized firm. The load bank shall be connected to the UPS system output at the maintenance bypass cabinet. The purpose of the load bank test is to ensure that circuitry is functional, that no shipping damage has occurred, and to verify the integrity of the installation.
2. After 4-hour burn-in test, transfer the UPS to static/internal bypass for 15 minutes and perform infrared scanning. Then transfer to maintenance bypass for 15 minutes and repeat infrared scanning. Transfers to occur while on full load.
3. Since the accuracy of the UPS system's panel instrumentation was proven during the factory testing, they shall be used for readings where practical. Load banks, cables, connectors and additional recording instruments required shall be furnished and installed by the UPS system supplier and the UPS manufacturer's authorized firm.
4. Completion of the load bank and battery load tests and cognizant Owner Representative signature evidencing approval shall constitute final acceptance of the UPS system and the commencement of the warranty period. The load bank testing will not be limited to, but shall include as a minimum, the following:
  - a. Apply power in the proper sequence.
  - b. Verify input and output AC and DC voltage and current reading on three phases of system output. Record data with power quality meters set up to record input and output voltage, current, frequency and transients of the output.
  - c. After 1/2 hours, verify that the battery system will support the full load for the specified time by interrupting the power inputs to the modules.
  - d. Perform block loading of the system including 0%-50%-0%; 25%-75%-25%; 0%-100%-0% while recording data with the power quality meters.
  - e. For the final fifteen (15) minute period, verify automatic and manual transfer functions of the UPS system to bypass, and back to UPS, by simulating conditions which would cause transfer (including UPS module emergency shutdown-EPO).
  - f. Verify proper activation of UPS system alarms and indicators including remote types during the test procedure.

D. Battery Rundown Test:

1. The test shall be conducted with each UPS module at full load.

- a. Remove the AC input and record the time and measure and record voltage drop across each battery connection under full load.
  - b. At thirty second intervals, record the DC voltage and current.
  - c. Record the time in which the battery discharge related alarm occurs
  - d. Conduct an infrared scan of the battery installation during discharge test.
  - e. Using the wave form recorder set at the highest resolution, record the critical load voltage and one phase input current prior to and during the entire input fail.
  - f. Continue to record without interruption for a minimum of five minutes to demonstrate the input walk-in current and the input current limit. These manual readings are required as well as automated data recording.
2. Upon successful completion of the battery tests and after the batteries have a chance to reach their normal charge and temperature, take a full set of cell voltage readings, specific gravity and cell temperature readings.
  3. After completion of installation and acceptance of battery system by the Owner, UPS supplier shall certify that installation is complete and in accordance with of UPS suppliers requirements and the UPS supplier warrantee is in effect.
- E. Damage, discrepancies, and/or parts replaced as a result of the load bank test shall be noted and the Owner/Engineer informed in writing. Battery system data recorded during the continuous monitoring period and the load test shall be submitted to the Owner/Engineer for analysis.
- F. If the system does not function properly, further tests shall be performed on item of equipment to determine whether it meets the pertinent specifications. Measurements deemed necessary by the Architect/Engineer shall be made. Modify or adjust item of equipment to meet the specifications for the particular item of equipment and the functional requirements of the complete system.
- G. Record system test results and corrective actions undertaken for submittal to the Owner at the time of system acceptance.
- H. An integral power system test designed to demonstrate the operation of the UPS system in conjunction with the emergency generators shall also be conducted by the Contractor with the assistance of the UPS supplier. The test shall extend for at least four (4) hours and shall prove the following:
1. Compatibility between the UPS system and the generators, i.e. harmonics shall not influence voltage regulation and the UPS input filter shall not affect the generators.
  2. Ability of the UPS system to synchronize the generator output.
  3. Ability of the UPS system to transfer the load from UPS system to maintenance bypass and back while on generator power.
  4. Ability of the UPS to limit battery recharge current while on generator power.

3.2 DEMONSTRATION

- A. UPS supplier shall provide qualified field service personnel as required to supervise the site tests. UPS supplier's field service technicians shall provide special instrumentations, including line disturbance analyzers, oscilloscopes and event recorders, required to perform the tests.
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain the UPS System.

**END OF SECTION**

## SECTION 26 33 55

### STATIC UPS (LARGE SYSTEM) TESTING AND COMMISSIONING

#### PART 1 - GENERAL

##### 1.1 SUMMARY

A. Section Includes:

1. System start-up and commissioning services.
2. Battery charging.
3. Load bank testing.
4. Battery load testing.
5. Integral system testing.
6. System demonstration.

B. Equipment, including load banks, measuring instruments, cables, connectors, etc. required for the site testing of the complete UPS system installation shall be provided by the UPS manufacturer's factory authorized firm. Installer shall assist and coordinate with the UPS manufacturer's factory authorized firm in the administration and performance of the site testing.

C. Related Requirements:

1. Division 01 Section 01 91 00 "Commissioning Requirements."

##### 1.2 INFORMATIONAL SUBMITTALS

A. Equipment List: Test equipment with make and model numbers. Test equipment shall have current calibration validation.

B. Field test reports and other documentation including a description of the test procedures and inspections with results listed for each test performed in a type-written format. Include results of tests, inspections and retests.

C. Battery test results including resistance measurements, voltage and temperature readings, specific gravity readings, load values and discharge times and other tests and inspections indicated.

D. Infrared scanning reports with pictures printed in a final report with deficiencies and actions taken to rectify.

#### PART 2 - PRODUCTS

A. (Not Used)

## PART 3 - EXECUTION

### 3.1 START-UP, COMMISSIONING, AND INTEGRATED SYSTEM TESTING

- A. Commissioning and testing of the UPS system shall be provided by Owner's Commissioning Agent. After installation, UPS supplier shall assign one or more qualified, experienced representatives to assist and supervise start-up commissioning.
1. Owner will advise UPS supplier at least 5 days in advance of the date when such supervisors will be required.
  2. Such supervisors shall meet with Owner and Owner's Commissioning Agent prior to system start-up to establish a mutually agreeable schedule for start-up and testing activities.
  3. Supervisors shall be assigned to work continuously until successful start-up completion.
  4. Installer shall assist and coordinate with the Owner's Commissioning Agent and the UPS system supplier's on-site support personnel in the administration and performance of the site testing and commissioning.
- B. Commissioning: UPS supplier shall provide on-site support for the duration of equipment commissioning. Include a minimum of 5 man-days for each system. Support shall be dedicated to this Project and assigned to work continuously until successful commissioning completion. A man-day shall be no more than up to 12 hours each day, Monday through Friday.
- C. Integrated System Testing: The UPS supplier shall provide on-site support for the duration of equipment integrated system testing. Include a minimum of 3 man-days for each system. Support shall be dedicated to this Project and assigned to work continuously until successful completion of integrated system testing. A man-day shall be no more than but up to 12 hours each day, Monday through Friday.
- D. System Start-Up:
1. After completion of UPS system installation and battery system certification, the following inspections and test procedures, as a minimum, shall be performed by UPS manufacturer's Field Engineers.
    - a. Visual Inspection:
      - 1) Compare equipment nameplate data with Drawings and Specifications.
      - 2) Inspect equipment for signs of damage incurred during delivery.
      - 3) Inspect anchorage, alignment, grounding and required clearances.
      - 4) Verify installation per drawings, including proper termination of cables.
      - 5) Inspect cabinets for foreign objects and remove if present.
      - 6) Verify phase, neutral and ground conductors are properly sized and configured.
      - 7) Verify date code on batteries to ensure batteries have been manufactured within the past 6 months. Return batteries to manufacturer with a date code indicating batteries are older than 6 months.

- 8) Verify battery racks and cabinets are seismically rated for the geographical location and installed as specified. Verify mounting, anchorage and alignment of battery racks and cabinets.
  - 9) Verify battery support rack and cabinet grounding and clearances.
  - 10) Verify battery systems are clean.
  - 11) Verify and inspect battery spill containment installation.
  - 12) Verify application of oxide inhibitor on battery terminal connections.
- b. Mechanical Inspection:
- 1) Check control wiring connections for tightness.
  - 2) Check power wiring connections for tightness.
  - 3) Check terminal screws, nuts, and/or spade lugs for tightness.
  - 4) Verify filters are in place and vents are clear.
  - 5) Verify battery area ventilation is operable.
  - 6) Verify existence of eyewash equipment as required by Drawings.
- c. Electrical Inspection:
- 1) Check fuses for continuity.
  - 2) Confirm input and bypass voltage and phase rotation is correct.
  - 3) Verify control transformer connections are correct for voltages being used.
  - 4) Assure connection and voltage of the battery string(s).
  - 5) Verify battery electrolyte levels and measure electrolyte specific gravity and temperature where applicable.
  - 6) Verify alarm indicating lamps and audible devices are operating properly. Record trip points either by simulation or actual fault condition. Indicate on documented procedure, which faults, were conducted by which means.

### 3.2 SITE TESTING

- A. In general, UPS system supplier shall be responsible for the performance of site tests on UPS system, including batteries, switchgears and disconnecting devices, as required to certify the proper operation of the system as a whole.
1. A recommended site test procedure shall be furnished by UPS system supplier and approved by Owner or Commissioning Agent.
  2. UPS supplier shall inspect the installation location of UPS system for the purpose of choosing locations for portable load bank installation.
  3. Testing shall be coordinated with Owner and may occur during normal working hours, overtime, or premium time hours.
- B. At a minimum, the following site tests are required:
1. Verify operating controls, alarms, meters, and mimic lights are functioning properly.
  2. Verify alarms function properly. Record trip points either by simulation or actual fault condition. Indicate on documented procedure, which faults, were conducted by which means.
  3. Verify all switchgear functions including all transfer capabilities.

#### STATIC UPS (LARGE SYSTEM) TESTING AND COMMISSIONING

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4. Conduct tests on air power circuit breakers in accordance with applicable ANSI/IEEE Standards, including but not limited to the following:
  - a. Insulation resistance tests pole-to-pole, pole-to-ground, across open poles and major insulation components.
  - b. Insulation resistance test on control wiring. For units with solid-state components or control devices, that cannot tolerate the applied voltages, follow the manufacturer's recommendations.
  - c. Primary current injection tests for breakers outside the UPS equipment. Verify components located in the UPS equipment have been factory tested and provide field testing of breakers as recommended by the manufacturer.
  - d. Contact resistance test using a Digital Low Resistance Ohmmeter.
  - e. Alignment test with master call to verify interfaces and interchangeability.
  - f. Mechanical and electrical operational tests.
  - g. Coil check test.
5. Voltage regulation: Record L-L voltage for each module for the system.
  - a. Record each module and system output voltage at no load.
  - b. Record each module and system output voltage at half rated load.
  - c. Record each module and system output voltage at full rate load.
  - d. Calculate the voltage regulation as follows:
    - 1)  $(NL-L)/NL \times 100 = \% \text{ Voltage regulation}$
    - 2) NL=No load volts
    - 3) L = 1/2 of full rated load volts
  - e. Verify multi-module systems are sharing the load evenly across modules per manufacturer's specifications.
6. Transient Tests:
  - a. A disturbance analyzer capable of capturing subcycle impulses shall be utilized with sufficient channels to monitor three-phase voltage output, single-phase current output, single-phase current input and single-phase voltage input.
  - b. Record system level voltages, current, kW and PF for both, input and output of steady state load steps prior to conducting test.
  - c. Example: Step load from 25% to 75%. Record the 25% load setting and the 75% load setting before performing the transient test.
  - d. Each transient test listed below shall be recorded and shall meet the following criteria, except when noted otherwise:
    - 1) Plus 8% or minus 8% with a recovery of 16 milliseconds to within plus or minus one percent of the initial steady state value. These criteria shall be met by each individual transient, measured line-to-line.
    - 2) The method of measuring a transient is as follows. The steady state voltage envelope prior to the transient measure in millimeters is subtracted from the peak-to-peak transient measure in millimeters. This absolute difference is divided by the steady state voltage envelope and multiplied by 100 to arrive at the percent transient.
  - e. Module Level Transient Response Tests: (Record operation times).

- 1) 0% to 50% to 0% of the full module load.
  - 2) 25% to 75% to 25% of the full module load.
  - 3) 50% to 100% to 50% of the full module load.
  - 4) 75% to 110% to 75% of the full module load.
  - 5) 0% to 100% to 0% of the full module load.
  - f. System Level Transient Response Tests: (Record operation times).
    - 1) 0% to 50% to 0% of the redundant load.
    - 2) 25% to 75% to 25% of the redundant load.
    - 3) 50% to 100% to 50% of the redundant load.
    - 4) 75% to 110% to 75% of the redundant load.
    - 5) 0% to 100% to 0% of the redundant load.
  - g. Repeat for the system operating in non-redundant mode.
  - h. UPS to Bypass Transfer Transients:
    - 1) With the entire system operating at full load, transfer the load from the UPS to the bypass and back to the UPS. Mark operation time.
    - 2) Repeat the test with the system operating in non-redundant mode.
  - i. Isolation Transients: With the entire system operating at full redundant load, simulate a blown fuse in one module. Observe the module removing itself from the output bus without affecting the load or the other UPS modules. Verify with disturbance analyzers there was no loss of load. Verify remaining modules share the load. Record transfer times. Simulate a blown fuse in the second module; verify that the system transfers to bypass.
  - j. Input Fail Transient: Test shall be conducted with a fully charged battery, with modules on-line and at full rate load. The system output voltage shall be monitored by the light beam recorder.
  - k. Note that the transients do not exceed the Specification or that the output modulation of each module does not exceed 1% as defined by the formula below:
    - 1)  $VM\% = (E_p \text{ MAX} - E_p \text{ MIN}) \times 100$
    - 2)  $E_p \text{ MAX} =$  Maximum phase voltage (peak-to-peak)
    - 3)  $E_p \text{ MIN} =$  Minimum phase voltage (peak-to-peak)
  - l. Remove the input power for one minute and then re-energize.
  - m. Repeat this test a total of three times to demonstrate consistency in performance.
  - n. Loss of Bypass: Remove the bypass line from the system input for 3 minutes. Reconnect the bypass and record the time until the UPS system synchronizes to the bypass.
7. Heat Run:
- a. Operate the entire system continuously for 8 hours at full reactive load. Load banks and cabling shall be provided by the installing Contractor. For the first four hours operate with modules on line. Immediately thereafter, operate the system with each module off sequentially for three hours. Complete the heat run with modules on line again. Perform step load transfers after heat run.
  - b. Record the system output voltage, current and frequency on each phase at one-hour time intervals to verify stability of the UPS output. Also monitor

and record the room temperature throughout the heat run. Perform an infrared scan of each mechanical connection in the critical path 15 minutes after full load has been reached and every 30 minutes during the testing period. Record pictures of the initial scan and put into a report for future reference.

8. System Battery Tests:

- a. The objective of this test is to verify the compatibility of the batteries with the associated UPS system and to verify the full load operation of each module for the reserve time and cut off voltage specified.
- b. Prior to the start of the test, the battery shall be floated at the required voltage for the time specified by the battery UPS supplier. Measure and record the resistance of inter-cell and inter-tier connections using a Digital Low Resistance Ohmmeter. Measure and record the internal-cell resistance of cells.
- c. Each module shall be tested with a 500 kW load that shall be maintained for a minimum of 15 minutes and to a DCUV (DC Under Voltage) trip at the cut off voltage of 1.67 volts/cell. Test shall be monitored with a battery monitoring system at the cell level. The module output voltage shall be recorded to verify compliance with the steady-state voltage regulation specified.
- d. After modules have been successfully load tested, recharge batteries of system for minimum of 3 hours (to 100% capacity), after which time perform system tests as specified.
- e. The test shall be conducted with each UPS module at the specified load. Remove the AC input and record the time and measure and record voltage drop across each battery connection under full load.
  - 1) At thirty second intervals, record the DC voltage and current.
  - 2) Record the time in which the battery discharge related alarm occurs and conduct an infrared scan of the battery installation.
  - 3) Using the wave form recorder running at highest resolution, record the critical load voltage and one phase input current prior to and during the entire input fail.
  - 4) Continue to record without interruption for a minimum of five minutes to demonstrate the input walk-in current and the input current limit.
  - 5) These manual readings are required as well as automated data recording.
- f. After successful completion of individual module testing, perform the following system tests at full load using a disturbance analyzer connected across system output.
  - 1) Open utility input breaker, record output voltage and current during input failure when inverter input transfers from rectifier to battery.
  - 2) Close utility input breaker, record output voltage and current during time when inverter input transfer from battery to rectifier.
  - 3) Fail UPS system, critical load transfers to UPS static by-pass utility input, record voltage and current during time, load transfers between inverter output and utility.

- 4) Re-establish UPS system output, critical load transfers from UPS static bypass to UPS output, record voltage and current during time, load transfers between static switch and inverter output.
- g. In order to test the Redundant/Non-redundant system feature, perform following tests with systems of 2 fully redundant 500KVA / 500 kW operating module systems), using a disturbance analyzer connected across system output, record output voltage and current:
  - 1) With a load of 500 kW, disable one module and the redundant module should power load without going to static bypass.
  - 2) With a load of more than 500 kW, disable one module, the redundant module cannot support load and load shall transfer to static bypass.
  - 3) With a load of 500 kW, system operates in 'redundant' fashion.
- h. Batteries shall be recharged to 95% of full charge within 12 times the discharge time. Record every thirty (30) minutes the input and output voltage, current, kW, pf, frequency and the DC voltage and current until the recharge requirement is met.
- i. Upon successful completion of the battery tests and after the batteries have a chance to reach their normal charge and temperature, take a full set of cell voltage readings, specific gravity and cell temperature readings.
- j. After completion of discharge testing, re-torque connections varying by more than  $\pm 10\%$  of average voltage.
- k. After completion of installation and acceptance of system by the Owner, UPS supplier shall certify that installation is complete and in accordance with of UPS supplier's requirements and the UPS supplier warrantee is in effect.
9. Synchronizing Circuit: The operation of the synchronizing circuits shall be demonstrated during the site acceptance-testing test.
10. Switchgear: UPS parallel output switchgear including circuit breakers shall be tested as described herein prior to being connected to the UPS System:
  - a. Inspect for physical damage.
  - b. Compare equipment nameplate information with latest single line diagram and report discrepancies.
  - c. Inspect for proper alignment, anchorage and grounding.
  - d. Check tightness of accessible bolted bus joints by calibrated torque wrench method. Refer to manufacturer's instructions for proper foot-pound levels.
  - e. Interlock systems shall be physically tested to ensure proper functions.
    - 1) Closure attempt shall be made on locked open devices. Opening attempt shall be made on locked closed devices.
    - 2) Key exchange shall be made with devices operated in off-normal positions.
  - f. Doors, panels and sections shall be inspected for paint, dents, scratches and fit.
  - g. Insulation Resistance Test:
    - 1) Measure insulation resistance of each bus section phase-to-phase and phase-to-ground for one (1) minute.
  - h. Test Values:

- 1) Insulation resistance test to be performed in accordance with the following:

<u>Voltage Rating</u>	<u>Test Voltage</u>
150-600V	1000V
601-5000V	2500V
5001 and above	5000V

- 2) Values of insulation resistance less than manufacturer's minimum or 100 megohms should be investigated. Overpotential tests should not proceed until insulation resistance levels are raised to said minimum.

- i. Circuit breaker draw-out mechanisms shall be inspected and adjusted as required for proper reliable operation. Each circuit breaker shall be racked in and out at least 5 times. Auxiliary switches shall be tested for proper and reliable operation. Circuit breakers shall be exchanged between cubicle without readjustment to assure a uniform standard of fit and adjustment.
- j. Installed circuit breaker options shall be verified against those required by the shop drawings with a report given to the Owner of deviations.
- k. Circuit breakers shall be tested and calibrated by means of primary injection and secondary injection.
- l. Circuit breakers shall be exercised at least 10 times to assure consistent mechanical and electrical operation of all functions.
- m. Conduct visual and mechanical inspections and electrical testing of switchgear assemblies in accordance with current NET ATS specifications.

- C. An integral power system test designed to demonstrate the operation of the UPS system in conjunction with the emergency generators shall also be conducted by the Contractor with the assistance of the UPS supplier. The test shall extend for at least four (4) hours and shall prove the following:

1. Compatibility between the UPS system and the generators, i.e. harmonics shall not influence voltage regulation and the UPS input filter shall not affect the generators.
2. Ability of the UPS system to synchronize the generator output.
3. Ability of the UPS system to transfer the load from UPS system to maintenance bypass and back while on generator power.
4. Ability of the UPS to limit battery recharge current while on generator power.
5. Infrared scanning of critical path mechanical connections shall be performed during integral power systems test.

### 3.3 DEMONSTRATION

- A. UPS supplier shall provide qualified field service personnel as required to supervise the site tests. UPS supplier's field service technicians shall furnish all special instrumentations, including line disturbance analyzers, oscilloscopes and event recorders, required to perform the tests.
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain UPS System

Project Name  
Project Number

Deliverable  
Issue Date

**END OF SECTION**

**SECTION 26 36 00**  
**TRANSFER SWITCHES**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes automatic transfer switches rated 600 V and less.

**1.2 ACTION SUBMITTALS**

- A. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Source quality-control test reports.
- B. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and maintenance data.

**1.5 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 NEMA ICS 1.
- C. Comply with NFPA 70.
- D. Comply with NFPA 99.
- E. Comply with NFPA 110.
- F. Comply with UL 1008 unless requirements of these Specifications are stricter.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Contactor Transfer Switches:
    - a. Emerson; ASCO Power Technologies, LP.
    - b. Russelectric, Inc.
  2. Transfer Switches Using Molded-Case Switches or Circuit Breakers:
    - a. Eaton Electrical Inc.; Cutler-Hammer.
    - b. GE Zenith Controls.
    - c. Hubbell Industrial Controls, Inc.

### 2.2 GENERAL TRANSFER SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- C. Solid-State Controls: Repetitive accuracy of settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
  2. Switch Action: Double throw; mechanically held in both directions.
  3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.



- G. Neutral Switching. Where four-pole switches are indicated, provide overlapping neutral contacts.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- J. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

## 2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- D. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- E. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase.
- F. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated.
- G. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer.
- H. Automatic Transfer-Switch Features:
  - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
  - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
  - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
  - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
  - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
  - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - b. Push-button programming control with digital display of settings.
  - c. Integral battery operation of time switch when normal control power is not available.

## 2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
  - 1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section 26 05 29 "Hangers and Supports."
- B. Identify components according to Division 26 Section 26 05 53 " Identification for Electrical Systems."
- C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### 3.2 CONNECTIONS

- A. Ground equipment according to Division 26 Section 26 05 26 "Grounding and Bonding."
- B. Connect wiring according to Division 26 Section 26 05 19 "Low-Voltage Conductors and Cables."

### 3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
  - 1. Retain first subparagraph below to require a factory-authorized service representative to assist Contractor with inspections, tests, and adjustments.
  - 2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
  - 3. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - 4. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 5. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - a. Check for electrical continuity of circuits and for short circuits.
    - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - c. Verify that manual transfer warnings are properly placed.
    - d. Perform manual transfer operation.

6. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    - e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    - f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
  7. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
    - a. Verify grounding connections and locations and ratings of sensors.
- C. Coordinate tests with tests of generator and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove access panels so joints and connections are accessible to portable scanner.
  1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
  2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- 3.4 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section 01 79 00 "Demonstration and Training."
  - B. Coordinate this training with that for generator equipment.

Project Name  
Project Number

Deliverable  
Issue Date

**END OF SECTION**

TRANSFER SWITCHES  
26 36 00 - 7

*Last Updated:*

*April 2022*

## SECTION 26 41 13

### LIGHTNING PROTECTION FOR STRUCTURES

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section includes lightning protection system for ordinary structures.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For air terminals and mounting accessories.
  - 1. Layout of the lightning protection system, along with details of the components to be used in the installation.
  - 2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality- control reports.

##### 1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Certified by UL, trained and approved for installation of units required for this Project.
- B. System Certificate:
  - 1. UL Master Label not required. Third party certification is required, VFC or equivalent firm.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

#### PART 2 - PRODUCTS

##### 2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96 and NFPA 780.
- B. Roof-Mounted Air Terminals: NFPA 780, Class I, aluminum unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ERICO International Corporation.
    - b. Harger.
    - c. Thompson Lightning Protection, Inc.
  2. Air Terminals More than 24 Inches (600 mm) Long: With brace attached to the terminal at not less than half the height of the terminal.
  3. Single-Ply Membrane, Roof-Mounted Air Terminals: Designed specifically for single-ply membrane roof system materials. Comply with requirements in roofing Sections.
- C. Main and Bonding Conductors: Aluminum.
- D. Ground Loop Conductor: The same size as the main conductor except tinned copper.
- E. Ground Rods: Copper-clad; 5/8 inch (16 mm) in diameter by 96 inches (2400 mm) long.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A and NFPA 780.
- B. Conceal the following conductors:
  1. System conductors.
  2. Down conductors.
  3. Interior conductors.
  4. Conductors within normal view of exterior locations at grade within 200 feet (60 m) of building.
- C. Cable Connections: Use crimped or bolted connections for conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.
- D. Cable Connections: Use exothermic-welded connections for conductor splices and connections between conductors and other components.
  1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
- 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.

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.
- 3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 00 "Common Work Results for Electrical."
- 3.3 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 cause deterioration or corrosion of conductors.
- 3.4 FIELD QUALITY CONTROL
- A. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- B. UL Inspection: Meet requirements to obtain a UL Master Label for system.
- C. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

**END OF SECTION**



## SECTION 26 43 13

### TRANSIENT VOLTAGE SUPPRESSION

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Service entrance voltage suppressors.

##### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.

##### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

##### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data.

##### 1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain suppression devices and accessories 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 IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."
- D. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- E. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

##### 1.6 PROJECT CONDITIONS

- A. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 30 to 120 deg F.
3. Humidity: 0 to 85 percent, noncondensing.
4. Altitude: Less than 20,000 feet above sea level.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advanced Protection Technologies, Inc.
  2. Current Technology, Inc.
  3. Square D; Schneider Electric.

### 2.2 SERVICE ENTRANCE SUPPRESSORS

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
1. LED indicator lights for power and protection status.
  2. Audible alarm, with silencing switch, to indicate when protection has failed.
  3. Fuses, rated at 200-kA interrupting capacity.
  4. Integral disconnect switch.
  5. Redundant suppression circuits.
  6. Surge-event operations counter.
- B. Peak Single-Impulse Surge Current Rating: 320 kA per phase.
- C. Connection Means: Permanently wired.
- D. Protection modes and UL 1449 suppressed voltage rating for grounded wye circuits with voltages of 480Y/277 or 208Y/120, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 800 V for 480Y/277 and 400 V for 208Y/120.
  2. Line to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
  3. Neutral to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
- E. Protection modes and UL 1449 suppressed voltage rating for 240/120-V, single-phase, 3-wire circuits shall be as follows:
1. Line to Neutral: 400 V.
  2. Line to Ground: 400 V.
  3. Neutral to Ground: 400 V.

- F. Protection modes and UL 1449 suppressed voltage rating for 240/120-V, 3-phase, 4-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 suppressed voltage rating for voltages of 240 or 480, 3-phase, 3-wire, delta circuits shall be as follows:
  - 1. Line to Line: 2000 V for 480 V and 1000 V for 240 V.
  - 2. Line to Ground: 2000 V for 480 V and 1000 V for 240 V.

### 2.3 PANELBOARD SUPPRESSORS

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
  - 1. LED indicator lights for power and protection status.
  - 2. Audible alarm, with silencing switch, to indicate when protection has failed.
  - 3. Fuses, rated at 200-kA interrupting capacity.
  - 4. Integral disconnect switch.
  - 5. Redundant suppression circuits.
  - 6. Surge-event operations counter.
  
- B. Peak Single-Impulse Surge Current Rating: 160 kA per phase.
  
- C. Protection modes and UL 1449 suppressed voltage rating for grounded wye circuits with voltages of 480Y/277 or 208Y/120, 3-phase, 4-wire circuits shall be as follows:
  - 1. Line to Neutral: 800 V for 480Y/277 and 400 V for 208Y/120.
  - 2. Line to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
  - 3. Neutral to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
  
- D. Protection modes and UL 1449 suppressed voltage rating for 240/120-V, single-phase, 3-wire circuits shall be as follows:
  - 1. Line to Neutral: 400 V.
  - 2. Line to Ground: 400 V.
  - 3. Neutral to Ground: 400 V.
  
- E. Protection modes and UL 1449 suppressed voltage rating for 240/120-V, 3-phase, 4-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 suppressed voltage rating for voltages of 240 or 480, 3-phase, 3-wire, delta circuits shall be as follows:
  - 1. Line to Line: 2000 V for 480 V and 1000 V for 240 V.
  - 2. Line to Ground: 1500 V for 480 V and 800 V for 240 V.

## 2.4 SUPPRESSORS FOR ELECTRONIC-GRADE PANELBOARDS

- A. Surge Protection Device Description: Sine-wave-tracking type, panel-mounted design with the following features and accessories:
  - 1. LED indicator lights for power and protection status.
  - 2. Audible alarm, with silencing switch, to indicate when protection has failed.
  - 3. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
- B. Peak Single-Impulse Surge Current Rating: 160 kA per phase.
- C. Protection modes and UL 1449 suppressed voltage rating for grounded wye circuits with voltages of 480Y/277 or 208Y/120, 3-phase, 4-wire circuits shall be as follows:
  - 1. Line to Neutral: 800 V for 480Y/277 and 400 V for 208Y/120.
  - 2. Line to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
  - 3. Neutral to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
- D. Protection modes and UL 1449 suppressed voltage rating for 240/120-V, single-phase, 3-wire circuits shall be as follows:
  - 1. Line to Neutral: 400 V.
  - 2. Line to Ground: 400 V.
  - 3. Neutral to Ground: 400 V.
- E. Protection modes and UL 1449 suppressed voltage rating for 240/120-V, 3-phase, 4-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 suppressed voltage rating for voltages of 240, 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:
  - 1. Line to Line: 2000 V for 480 V and 1000 V for 240 V.
  - 2. Line to Ground: 1500 V for 480 V and 800 V for 240 V.

## 2.5 ENCLOSURES

- A. NEMA 250, with type matching the enclosure of panel or device being protected.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF SURGE PROTECTION DEVICES

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install devices for panelboard and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
  - 1. Provide multipole, 30-A circuit breaker as a dedicated disconnect for suppressor, unless otherwise indicated.

### 3.2 PLACING SYSTEM INTO SERVICE

- A. Do not energize or connect service entrance equipment or panelboards to their sources until surge protection devices are installed and connected.

### 3.3 FIELD QUALITY CONTROL

- A. Testing: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports:
- B. Testing: Perform the following field tests and inspections and prepare test reports:
  - 1. Complete startup checks according to manufacturer's written instructions.
  - 2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.

**END OF SECTION**

**SECTION 26 51 00**  
**INTERIOR LIGHTING**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Interior lighting fixtures, lamps, and ballasts.
  - 2. Emergency lighting units.
  - 3. Exit signs.
  - 4. Lighting fixture supports.

**1.2 DEFINITIONS**

- A. Lumen: Measured output of lamp and luminaire, or both.
- B. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Arrange in order of luminaire designation.
  - 2. Include data on features, accessories, and finishes.
  - 3. Include physical description and dimensions of luminaires.
  - 4. Include battery and charger data for emergency lighting units.
  - 5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and installation connection details, accessories.
- C. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.
  - 1. Include Samples of luminaires and accessories involving color and finish selection.
- D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Photometric Data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

1. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
  2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
- B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- C. Field quality-control reports.
- 1.5 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
- 1.6 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. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- 1.7 DELIVERY, STORAGE, AND HANDLING
- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide product indicated on Drawings.
- B. Provide luminaires from a single manufacturer for each luminaire type.

## 2.2 GENERAL 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 for hazardous locations 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.
- E. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- F. Nominal Operating Voltage: As indicated on Drawings.
- G. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- H. Fluorescent fixtures are not permitted
- I. HID fixtures are not permitted
- J. Metal Parts: Free of burrs and sharp corners and edges.
- K. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- L. Air-Handling Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 23 Section 23 37 13 "Diffusers, Registers, and Grilles."
- M. 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.
- N. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels 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.
- O. NRTL Compliance: RTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.



## 2.3 LUMINAIRES

- A. Nominal Operating Voltage: 277V AC, unless noted otherwise on fixture schedule or if the facility does not have this voltage available.
- B. Lamp:
  - 1. Minimum 500lm, unless noted otherwise or as scheduled.
  - 2. Minimum allowable efficacy of 80 lm/W.
  - 3. CRI of minimum 80. CCT of 4000 K. Unless noted otherwise or as scheduled.
  - 4. Rated lamp life of minimum 50,000 hours to L70.
  - 5. Dimmable from 100 percent to 1 percent of maximum light output.
  - 6. Internal driver.
  - 7. User-Replaceable Lamps:
    - a. Bulb shape complying with ANSI C78.79.
    - b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- C. Housings:
  - 1. Extruded-aluminum housing and heat sink.
  - 2. Clear powder-coat finish. Finish as scheduled and per interior designer.
  - 3. Universal mounting bracket.
  - 4. Integral junction box with conduit fittings.
- D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- E. Diffusers and Globes:
  - 1. Fixed or adjustable lens as scheduled.
  - 2. Light distribution as scheduled.
  - 3. Tempered glass, or as scheduled.
  - 4. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
  - 5. Glass: Annealed crystal glass unless otherwise indicated.
  - 6. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
- F. With integral mounting provisions.
- G. Standards:
  - 1. ENERGY STAR certified.
  - 2. RoHS compliant.
  - 3. UL Listing: Listed for damp location.

## 2.4 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
  - 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
  - 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
    - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
    - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
    - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
    - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

## 2.5 EMERGENCY LIGHTING UNITS

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
  - 1. Battery: Sealed, maintenance-free, lead-acid type.
  - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
  - 3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
  - 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
  - 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

## 2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with Division 26 Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use permanent luminaires for temporary lighting. Install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires; disassemble, clean, and install new lamps; and reinstall luminaires.

### 3.3 OFFICE ENVIRONMENTS

- A. Provide direct/indirect fixtures or indirect fixtures to reduce glare.

### 3.4 WAREHOUSE, MANUFACTURING, AND OTHER "HIGH BAY" APPLICATIONS

- A. Choose fixtures and lamps such that glare is not an issue.

### 3.5 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
  - 1. Sized and rated for luminaire weight.
  - 2. Able to maintain luminaire position after cleaning and relamping.

3. Provide support for luminaire without causing deflection of ceiling or wall.
  4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaires:
1. Secured to outlet box.
  2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
  3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaires:
1. Attached to structural members in walls.
  2. Do not attach luminaires directly to gypsum board.
- G. Suspended Luminaires:
1. Ceiling Mount:
    - a. Two 5/32-inch- (4-mm-) diameter aircraft cable supports 10 feet (3 m) in length.
    - b. Pendant mount with 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 10 feet (3 m) in length.
    - c. Hook mount.
  2. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
  3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
  4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
  5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- H. Ceiling-Grid-Mounted Luminaires:
1. Secure to any required outlet box.
  2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
  3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.
- I. Comply with requirements in Division 26 Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

- J. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
- K. Adjust aimable lighting fixtures to provide required light intensities.
- L. Connect wiring according to Section Division 26 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

### 3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Install wiring labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

### 3.7 FIELD QUALITY CONTROL

- A. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- B. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

**END OF SECTION**

**SECTION 26 56 00**  
**EXTERIOR LIGHTING**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This section includes the following:
  - 1. Exterior luminaires with lamps and drivers.
  - 2. Luminaire-mounted photoelectric relays.
  - 3. Poles and accessories.
  
- B. Related Requirements:
  - 1. Division 26 Section 26 51 00 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

**1.2 ACTION SUBMITTALS**

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, and finishes.
  
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and installation connection details, accessories.
  - 1. Include plans, elevations, sections, and mounting and attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Detail fabrication and assembly of poles and pole accessories.
  - 4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
  - 5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
  - 6. Method and procedure of pole installation. Include manufacturer's written installations.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design.
  - 1. Certification shall be based on design calculations signed and sealed by a professional engineer.

- B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- C. Field quality-control reports.
- D. Sample Warranty: Manufacturer's standard warranty.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For poles and luminaire-lowering devices to include in emergency, operation, and maintenance manuals.

#### 1.5 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. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- C. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

#### 1.6 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
  - 1. Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

- B. Provide luminaires from a single manufacturer for each luminaire type.

## 2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Division 01 Section 01 40 00 "Quality Requirements," to design pole foundation and pole power system.
- B. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied as stated in AASHTO LTS-4.
- C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
  - 1. Wind speed for calculating wind load for poles exceeding 50 feet in height: 90 mph.
  - 2. Wind speed for calculating wind load for poles 50 feet or less in height: 90 mph.
- D. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

## 2.3 LUMINAIRES, GENERAL

- 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 and CCT of 4000K unless otherwise indicated.
- H. Rated lamp life of minimum 50,000 hours to L70.
- I. Lamps dimmable from 100 percent to 1 percent of maximum light output.
- J. Internal driver.
- K. Mounting method, orientation and height as scheduled / specified.



- L. Distribution type as scheduled / specified.
- M. Nominal Operating Voltage: 277V AC, unless noted otherwise on fixture schedule or if the facility does not have this voltage available.
- N. In-line Fusing: Separate in-line fuse for each luminaire.
- O. Lamp Rating: Lamp marked for outdoor use.
- P. Source Limitations: Obtain luminaires from single source from a single manufacturer.
- Q. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

## 2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. 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.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. 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.
- G. 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.

- H. 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.

## 2.5 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, match 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: As specified, or to match fixtures of similar type in same area.
- 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 by Architect from manufacturer's full range.

## 2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Division 26 Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

## 2.7 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 and off at 4.5 to 10 fc 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 NEMA C136.10.
  - 2. Adjustable window slide for adjusting on-off set points.

## 2.8 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4.
  - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
  - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
  - 3. Anchor-Bolt Template: Plywood or steel.
  - 4. Light poles shall have attachments for security cameras.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
  - 1. Materials: Shall not cause galvanic action at contact points.
  - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
  - 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section 03 33 00 "Cast-in-Place Concrete."
- E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to

ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

- F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.
- G. Refer to security or electrical plans for locations of security cameras on poles and include suitable mount / bolt pattern for the security camera junction box.

## 2.9 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; 1-piece construction up to 40 feet in height with access handhole in pole wall.
  - 1. Shape: Refer to drawings.
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
  - 1. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
  - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
  - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet above finished grade.
- F. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section 26 05 26 "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- G. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- H. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- I. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.

- J. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Color shall be as selected by Architect.

## 2.10 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.
- B. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- C. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section 26 05 26 "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- D. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
  - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
  - 2. Finish: Same as luminaire.
- E. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- F. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Color shall be as selected by Architect from manufacturer's full range.

## 2.11 POLE ACCESSORIES

- A. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- B. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- C. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept indicated accessories.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.
- C. Examine roughing-in for foundation and conduit to verify actual locations of installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

### 3.3 POLE INSTALLATION

- A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
- C. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer.
  - 1. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
  - 2. Install base covers, unless otherwise indicated.
  - 3. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- D. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
  - 1. Dig holes large enough to permit use of tampers in the full depth of hole.
  - 2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- E. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height and in accordance with the SRP standard details
  - 1. Cure concrete a minimum of 72 hours before performing work on pole.
- F. Raise and set poles using web fabric slings (not chain or cable).

### 3.4 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

### 3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top 4 inches (verify with Drawings) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

### 3.6 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section 26 05 33 "Raceways and Boxes." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

### 3.7 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section 26 05 26 "Grounding and Bonding."
  - 1. Install grounding electrode for each pole, unless otherwise indicated.
  - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section 26 05 26 "Grounding and Bonding."
  - 1. Install grounding electrode for each pole.
  - 2. Install grounding conductor and conductor protector.
  - 3. Ground metallic components of pole accessories and foundations.

### 3.8 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section 26 05 53 "Identification for Electrical Systems."

Project Name  
Project Number

Deliverable  
Issue Date

**END OF SECTION**

EXTERIOR LIGHTING  
26 56 00 - 11

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