PROJECT MANUAL

El Dorado County Transit Authority
Bus Parking Lot Improvements
Project 23-02 (2)

Diamond Springs, California

Prepared by
Enterprise Engineering, Inc

6565 Commerce Way
Diamond Springs California 95619

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SECTION 11 11 36 - VEHICLE CHARGING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Offboard electric vehicle charging system equipment.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" specifies concrete bases.
2. Section 260553 "Identification for Electrical Systems" specifies identification products.

1.2 DEFINITIONS

A. CCS: Combined charging system; a means for using the same connector port for both AC Level 2 charging and DC Level 3 fast charging.

B. EV: Electric vehicle.

C. EVCE: Electric vehicle charging system equipment. This term refers to DC Level 3 charging equipment located offboard the vehicle.

D. EVSE: Electric vehicle supply equipment. This term refers to AC Level 2 charging equipment that depends on the built-in charger located onboard the vehicle.

E. Fastened in Place: Does not require tools to be removed and replaced.

F. Fixed in Place: Requires tools to be removed and replaced.

G. NICET: National Institute for Certification in Engineering Technologies; a division of the National Society of Professional Engineers (NSPE).

H. OCPP: Open Charge Point Protocol; an application protocol for communication between EVs and a central management system.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of

qualified electrical testing agency, certifying product's compliance with specified listing criteria.

a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.

2. Include manufacturer's sample extended warranty language.

B. Shop Drawings: Prepare and submit the following:

1. Routing and attachment of permanent wiring.

a. Include plans, elevations, sections, details, and attachments to other work.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Preconstruction test reports.

B. Manufacturer's published instructions.

C. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Manufacturer's field reports for system startup support.
3. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

B. Software and firmware service agreement.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Spare parts.

B. Special tools.

1.7 QUALIFICATIONS

A. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.

B. Communications Cable Installer: Entity possessing active qualifications and the following:

1. Training and manufacturer certification to install, splice, and terminate communications cabling.
2. Installation Supervisor: BICSI Technician (TECH) certification.

C. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site communications testing supervisor must have BICSI Technician (TECH) certification and documented training, and be experienced with testing communications equipment in accordance with BICSI testing standards.

1.8 PRECONSTRUCTION TESTING

A. Wireless Survey: Complete wireless survey to determine if wireless provider signals meet or exceed manufacturer's recommended minimum values.

B. Preconstruction Test Reports: Collect, assemble, and submit test reports prepared by qualified testing agency.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 OFFBOARD ELECTRIC VEHICLE CHARGING SYSTEM EQUIPMENT

A. Description: EVCE located offboard the vehicle that is designed for providing DC Level 3 fast charging of vehicle batteries.

B. UL FFTG - DC Level 3 EV Charging System Equipment (EVCE):

1. Manufacturers: Subject to compliance with requirements, available

manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ChargePoint, Inc.; subsidiary of ChargePoint Holdings, Inc.; Express Plus
b. ABB
c. Heliox (Siemens Business)

2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. EVCE: UL CCN FFTG; including UL 2202.
b. Personnel Protection: UL CCN FFUQ2; including UL 2231-1 and UL 2231-2.

4. Standard Features: Complies with Article 625 of NFPA 70.
5. Sustainable Design Features:

a. Lead Content for Electrical Wire and Cable: Less than 300 ppm.
b. Equipment has earned ENERGY STAR product label.
c. Regional Materials (LEED): Provide documentation if product is sourced (extracted, manufactured, or purchased) within **100 miles** of Project site.

6. Other Available Features Required by the Project:

a. Location Rating: Outdoor.
b. Input Feeder Rating: 480Y/277 V(ac), three phase, 60 Hz, 350 A.
c. Output Quantity: 2.
d. Output Wiring: Flexible cord.

1) Output Cable Nominal Length: 25 ft. (horizontal reach of 20 ft)
2) Cable management system.
3) Output Attachment Plug: CCS Combo 1 (SAE J1772).

e. Mounting: Concrete base mount.
f. Metering: Nonrevenue grade meter.

7. Accessories:

a. Multifunctional Display: Provide electronic signage integral with charger pedestal that is capable of displaying operating instructions, video advertising, and other messages while charger is in operation.

2.3 MAINTENANCE MATERIAL ITEMS

A. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to vehicle charging equipment, that are packaged with protective covering for storage on-site and identified

with labels describing contents.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, and bollards or posts for suitable conditions where vehicle charging equipment will be installed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF VEHICLE CHARGING EQUIPMENT

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
4. Communications Work: BICSI N1.
5. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
6. Electric Vehicle Power Transfer System: Article 625 of NFPA 70 and NECA NEIS 413.
7. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Hard-Wired Connection: Provide safety switch, that is lockable in "Off" position, in readily accessible location for termination of input cable.
2. Fastened in Place: Comply with manufacturer's published instructions for installing mounting hardware. Provide manufacturer's recommended seismic controls when required for compliance with the Project's requirements.
3. Fixed in Place: Comply with manufacturer's published instructions for installation and torquing of hardware fasteners. Provide manufacturer's recommended seismic controls when required for compliance with the Project's requirements.
4. Base Mounting: When indicated on Drawings or in manufacturer's published instructions, provide concrete bases for installing vehicle charging equipment.
5. Identification: Provide labels for vehicle charging equipment and associated electrical equipment.

    a. Identify field-installed conductors, interconnecting wiring, and components.
    b. Provide warning signs.
    c. Label each enclosure with engraved metal or laminated-plastic nameplate.

D. Cybersecurity:

1. Software:

a. Coordinate security requirements with IT department.
b. Ensure that latest stable software release is installed and properly operating.
c. Disable or change default passwords to password of at least eight characters in length, using a combination of uppercase and lower letters, numbers, and symbols. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

a. Coordinate location and access requirements with IT department.
b. Enable highest level of wireless encryption that is compatible with Owner's information and communications technology network.
c. Disable dual network connections.

E. Interfaces with Other Work:

1. Coordinate installation of new vehicle charging equipment with existing conditions.
2. Work must be rated to handle available fault current on input feeder.
3. Provide appropriate warning labels for arc-flash hazard on input feeder.

3.3 FIELD QUALITY CONTROL OF VEHICLE CHARGING EQUIPMENT

A. Administrant for Electrical Power Tests and Inspections:

1. Engage qualified electrical power testing and inspecting agency to administer and perform tests and inspections.
2. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

B. Administrant for Communications Tests and Inspections:

1. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Field tests and inspections must be witnessed by Owner.

D. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

2. For each unit of vehicle charging equipment, perform the following tests and inspections:

    a. Unit self-test.
    b. Operation test with load bank.
    c. Operation test with EV.
    d. Network communications test.

E. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.4 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.

B. Manufacturer Services: Engage factory-authorized service representative to support system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 PROTECTION

A. After installation, protect vehicle charging equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.6 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for two years.
2. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 11 11 36

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermoplastic-insulated wire.
2. Thermoset-insulated wire.
3. Connectors and splices.

B. Related Requirements:

1. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
2. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
3. Section 260533.13 "Conduits for Electrical Systems" specifies installation of raceways referenced by this Section.
4. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.

1.2 DEFINITIONS

A. NICET: National Institute for Certification in Engineering Technologies; a division of the National Society of Professional Engineers (NSPE).

1.3 ACTION SUBMITTALS

A. Product Schedule: Indicate type, use, location, and termination locations.

B. Product Data: For each type of product.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

1.5 QUALIFICATIONS

A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III

certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 THERMOPLASTIC-INSULATED WIRE

A. Description: Thermoplastic-insulated wire for use in accordance with Article 310 of NFPA 70.

B. UL ZLGR - Type THWN-2 Insulated Wire:

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

    a. Alpha Wire; brand of Belden, Inc.
    b. Cerro Wire LLC
    c. Encore Wire Corporation
    d. Okonite Company (The)
    e. Southwire Company, LLC

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.

3. Standard Features:

    a. Referenced Standard: Article 310 of NFPA 70.
    b. Insulation Voltage Rating: 600 V.
    c. Conductor Material: Copper.
    d. Conductor Size: As indicated on the Drawings.

        1) Minimum Conductor Size: 12 AWG.

2.3 THERMOSET-INSULATED WIRE

A. Description: Thermoset-insulated wire for use in accordance with Article 310 of NFPA 70.

B. UL ZKST - Type XHHW-2 Insulated Wire:

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

    a. Cerro Wire LLC
    b. Encore Wire Corporation
    c. Okonite Company (The)
    d. Southwire Company, LLC

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.

3. Standard Features:

    a. Referenced Standard: Article 310 of NFPA 70.
    b. Insulation Voltage Rating: 600 V.
    c. Conductor Material: Copper.
    d. Conductor Size: As indicated on the Drawings.

        1) Minimum Conductor Size: 12 AWG.

2.4 CONNECTORS AND SPLICES

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

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

    a. 3M Electrical Products
    b. Crouse-Hinds; brand of Eaton, Electrical Sector
    c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated
    d. O-Z/Gedney; brand of Appleton Group

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the

following UL product categories:

a. Type AC and Type MC Cable Connectors: UL CCN PJOX, including UL 514B.

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

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

1. Material: Copper.
2. Type: Two hole with standard barrels
3. Termination: Crimp

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:

1. Material: Copper.

a. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

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

B. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

C. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

3.3 INSTALLATION OF LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.

C. Special Installation Techniques:

1. Complete raceway installation between conductor and cable termination points prior to pulling conductors and cables.
2. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
4. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
5. Provide support for cables.
6. Connections:

    a. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
    b. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

        1) Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
3. Perform each of the following visual and electrical tests:

    a. Inspect exposed sections of conductor and cable for physical damage and correct connection in accordance with the single-line diagram.
    b. Test bolted connections for high resistance using one or more of the following:

1) A low-resistance ohmmeter.
2) Calibrated torque wrench.
3) Thermographic survey.

c. Inspect compression-applied connectors for correct cable match and indentation.
d. Inspect for correct identification.
e. Inspect cable jacket and condition.
f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

B. Nonconforming Work:

1. Wire or cable assembly will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding systems and equipment.

B. Related Requirements:

1. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

B. Shop Drawings: Prepare and submit the following:

1. Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:

a. Grounding electrode access enclosures.
b. Grounding electrodes.

C. Sustainable Design Submittals:

1. Product data for sustainable design features for each type of product.

D. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

1.4 QUALIFICATIONS

A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. System Description

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

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

1. Galvan Industries, Inc.; Electrical Products Division, LLC.
2. Harger Lightning & Grounding.
3. Hubbell Incorporated (Burndy)
4. ILSCO

2.3 CONDUCTORS

A. Equipment Grounding Conductor:

1. Standard Features: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Standard Features: Complying with one or more of the following:

a. Soft or Annealed Copper Wire: ASTM B3.
b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

2.4 GROUNDING AND BONDING CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

D. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

E. Conduit Hubs: Mechanical type, terminal with threaded hub.

F. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

G. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

2.5 GROUNDING (EARTHING) ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

2.6 GROUNDING ELECTRODE ENCLOSURES

A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.

B. Grounding Electrode Access Well Enclosure:

1. Source Limitations: Obtain products from single manufacturer.
2. Standard Features:

a. Well Material: Concrete.

b. Cover Material: Cast iron.
c. Cover Strength: Sidewalk or turf use.

PART 3 - EXECUTION

3.1 SELECTION OF GROUNDING AND BONDING PRODUCTS

A. Grounding and Bonding Conductors:

1. Provide solid conductor for 8 AWG wire size and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
2. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, **1/4 inch** in diameter.
3. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
4. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; **1-5/8 inch** wide and **1/16 inch** thick.

B. Grounding and Bonding Connectors:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.

3.2 INSTALLATION OF GROUNDING AND BONDING

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.

C. Special Techniques:

1. Grounding and Bonding Conductors:

a. 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. Underground Grounding Conductors:

1) Bury at least **30 inch** below grade.
2) Duct-Bank Grounding Conductor: Bury **12 inch** above duct bank when indicated as part of duct-bank installation.

2. Grounding and Bonding Connectors: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
b. Make connections with clean, bare metal at points of contact.
c. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.

3. Electrodes:

a. Ground Rods: Drive rods until tops are **2 inch** 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) Use exothermic welds for below-grade connections.

b. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least **12 inch** deep, with cover.

1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

c. Ring Electrode: Install grounding conductor, electrically connected to each building structure ground rod and to eachindicated item, extending around perimeter of area or item indicated.

1) Install tinned-copper conductor not less than 2/0 AWG for ring electrode and for taps to building steel.

4. Grounding at Service:

a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.

5. Grounding Underground Distribution System Components:

a. Comply with IEEE C2 grounding requirements.
b. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so **4 inch** will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from **2 inch** above to **6 inch** below concrete. Seal floor opening with waterproof, nonshrink grout.
c. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.
d. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than **6 inch** from foundation.

6. Equipment Grounding and Bonding:

a. Install insulated equipment grounding conductors with feeders and branch circuits.
b. 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) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

c. Metallic Fences: Comply with requirements of IEEE C2.

1) Grounding Conductor: Bare copper, not less than 8 AWG.

2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
3) Barbed Wire: Strands must be bonded to grounding conductor.

3.3 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

A. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by 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 in accordance with IEEE Std 81.
    c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to record of tests and observations. Include number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Nonconforming Work:

1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

C. Collect, assemble, and submit test and inspection reports.

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

    a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω.
    b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω.
    c. Power and Lighting Equipment or System with Capacity More Than 1000

kVA: 3 Ω.

3.4 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 05 26

SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.

B. Related Requirements:

1. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
2. Section 260553 "Identification for Electrical Systems" specifies underground-line warning tape and concrete cable routing markers (warning planks).

1.2 DEFINITIONS

A. Duct: A single raceway or multiple raceways, installed singly or as components of a duct bank.

B. Duct Bank: Two or more ducts installed in parallel, direct buried or with additional casing materials such as concrete.

C. Handhole: An underground chamber containing electrical cables, sized such that personnel are not required to enter in order to access the cables.

D. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include warning tape.
4. Handholes and boxes.

1.4 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

B. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

D. Source quality-control reports.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Comply with ANSI C2.

2.2 CONDUIT

A. RNC: NEMA TC 2, Type EPC-40-PVC with type EPC-80-PVC elbows, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

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. ARNCO Corp.
2. Beck Manufacturing
3. Cantex, Inc.
4. Condux International, Inc.
5. Electri-Flex Company

6. IPEX Inc.

B. Solvents and Adhesives: As recommended by conduit manufacturer.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems".

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

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

B. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

1. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Cover Legend: Molded lettering, "LIGHTING" or “ELECTRIC”, based on wiring.
3. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
4. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension shall provide increased depth of 12 inches (300 mm).
    b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

5. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

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

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by owner.

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC with EPC-80-PVC elbows, direct buried unless otherwise indicated.

B. Duct for DC voltage for EV Charger Circuits: RNC, NEMA Type EPC-40-PVC with EPC-80-PVC elbows, concrete encased unless otherwise indicated.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with the Greenbook, but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.4 DUCT INSTALLATION

A. Install ducts according to NEMA TCB 2.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.

C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 36 inches, both horizontally and vertically, at other locations unless otherwise indicated.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

F. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in empty ducts.

G. Concrete-Encased Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in the Green Book for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 3 inch wider than duct on each side.
3. Depth: Install so top of duct envelope is at least **30 inch** below finished grade in areas not subject to deliberate traffic, and at least **30 inch** below finished grade in deliberate traffic paths for vehicles unless otherwise indicated. Install so top of duct envelope is below local frost line.
4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per **20 ft** of duct. Place spacers within **24 inch** of duct ends. Stagger spacers approximately **6 inch** between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
6. Minimum Space between Ducts: **3 inch** between edge of duct and exterior envelope wall, **2 inch** between ducts for like services, and **12 inch** between power and communications ducts.
7. Elbows:

    a. Use manufactured duct elbows for stub-ups and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
    b. Use manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct run.

8. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of **60 inch** from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment .

    a. Stub-ups must terminate in coupling installed flush with finished floor and minimum **3 inch** from conduit side to edge of slab.

9. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
10. Concrete Cover: Install minimum of **3 inch** of concrete cover between edge of duct to exterior envelope wall, **2 inch** between duct of like services, and **6 inch** between power and communications ducts.
11. Place minimum **6 inch** of engineered fill above concrete encasement of duct.
12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

a. Start at one end and finish at other, allowing for expansion and contraction of duct as its temperature changes during and after pour. Use expansion fittings installed in accordance with manufacturer's published instructions, or use other specific measures to prevent expansion-contraction damage.
b. If more than one pour is necessary, terminate each pour in vertical plane and install **3/4 inch** reinforcing-rod dowels extending minimum of **18 inch** into concrete on both sides of joint near corners of envelope.

H. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in 700 of the White Book for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than five spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.
4. Width: Excavate trench 3 inch wider than duct on each side.
5. Depth: Install top of duct at least 30 inch below finished grade unless otherwise indicated.
6. Set elevation of top of duct bank below frost line.
7. Install duct with minimum of 2 **inch** between ducts for like services and **6 inch** between power and communications duct.
8. Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
9. Install manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct.

    a. Couple RNC duct to steel raceway with adapters designed for this purpose, and encase coupling with minimum **3 inch** of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of **60 inch** from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups must terminate in coupling installed flush with finished base and minimum **3 inch** from conduit side to edge of base.

10. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to **4 inch** over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving"

for installation of backfill materials.

a. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.

I. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.5 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

A. Precast Concrete Handhole Installation:

1. Comply with ASTM C891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
2. Where indicated, cast handhole cover frame integrally with handhole structure.
3. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
4. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three days. After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars.
5. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms,as required for installation and support of cables and conductors and as indicated.
6. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than **3-7/8 inch** for manholes and **2 inch** for handholes, for anchor bolts installed in field. Use minimum of two anchors for each cable stanchion.
7. Ground manholes, handholes, and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 GROUNDING

A. Ground underground ducts according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 6-inch-long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

3.8 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 26 05 43

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels
2. Bands and tubes
3. Tapes and stencils
4. Signs
5. Cable Ties
6. Miscellaneous identification products

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

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

C. Delegated-Design Submittal: For arc-flash hazard study

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2

B. Comply with NFPA 70

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145

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

E. Comply with OSHA requirements for electrical labeling

F. Comply with NFPA 70E requirements for arc-flash warning labels

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

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

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

2.2 COLOR AND LEGEND REQUIREMENTS

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

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
2. Colors for 480/277-V Circuits:

a. Phase A: Brown
b. Phase B: Orange
c. Phase C: Yellow

3. Color for Neutral: White
4. Color for Equipment Grounds: Green

B. Color-Coding for DC Power Circuit Wiring Identification: Use colors listed below for ungrounded feeder and branch circuit conductors

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit
2. Colors for DC Circuits:

a. Positive: Red
b. Negative: Black
c. Protective Ground: Green

C. Equipment Identification Labels:

1. Black letters on a white field

2.3 LABELS

A. Self-Adhesive Vinyl Labels: Preprinted, 3-mil- (0.08-mm-) thick, vinyl flexible label with acrylic pressure-sensitive adhesive

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

a. Brady Corporation
b. Brother International Corporation
c. Ideal Industries, Inc.
d. Panduit Corp

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
3. Marker for Labels:

a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation
b. HellermannTyton
c. Marking Services, Inc.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

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

a. Brady Corporation
b. Panduit Corp
c. TE Connectivity

2.5 TAPES AND STENCILS

A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, available

manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Brady Corporation
b. Carlton Industries, LP
c. Emedco

B. Underground-Line Warning Tape:

1. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".

2.6 SIGNS

A. Baked-Enamel Signs

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

a. Carlton Industries, LP
b. Champion America
c. Ideal Industries, Inc.

2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Laminated Acrylic or Melamine Plastic Signs.

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

a. Brady Corporation

b. Carlton Industries, LP
c. Emedco

C. Equipment Identification Labels

1. Engraved legend
2. Thickness:

a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
c. Engraved legend with black letters on white face.
d. Self-adhesive
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

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. HellermannTyton
2. Ideal Industries, Inc.
3. Marking Services Inc.
4. Panduit Corp

B. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.

C. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel

machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

C. Electrical Hazard Warnings:

1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with NFPA 70E requirements for arc-flash hazard warning labels.

3.3 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

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

F. System Identification for Raceways and Cables under 600 V: Identification shall

completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

H. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. “Power”

I. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

J. Self-Adhesive Vinyl Labels: Secure tight to surface at a location with high visibility and accessibility.

K. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

L. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

O. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

P. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

Q. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.

3.4 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

E. Arc Flash Warning Labeling: Self-adhesive labels.

F. Equipment Identification Labels

1. Indoor/Outdoor Equipment: Laminated acrylic or melamine sign.
2. Equipment to be Labeled:

a. Switchboards
b. Panelboards
c. Transformers
d. Enclosed Circuit Breakers
e. Transfer Switch
f. Power Blocks
g. EV Chargers

END OF SECTION 26 05 53

SECTION 26 05 73 - POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Short-circuit study.
2. Overcurrent protective device coordination study.
3. Arc-flash hazard study.

1.2 ACTION SUBMITTALS

A. Product Data: For power system analysis software to be used for studies.

1. Product Certificates: For power system study software applications, include certificate stating compliance with specified requirements, signed by software manufacturer.

B. Power System Study Reports:

1. Submit reports after approval of system protective devices submittals. Submittals may be in digital form.
2. Submit short-circuit study input data, including completed computer-program input data sheets.
3. Submit coordination study input data, including completed computer-program input data sheets.
4. Submit arc-flash study input data, including completed computer-program input data sheets.

1.3 QUALITY ASSURANCE

A. Submittals for power system studies must be signed and sealed by qualified electrical professional engineer responsible for their preparation.

B. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

C. Software algorithms must comply with requirements of standards and guides specified in this Section.

D. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

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. CYME International T&D Inc.; subsidiary of Eaton Corporation plc
2. EasyPower; brand of Bentley Systems, Inc.
3. ETAP; brand of Operation Technology, Inc.; subsidiary of Schneider Electric
4. Power Tools for Windows (PTW); brand of SKM Systems Analysis, Inc.

B. Standard Features:

1. Power System Analysis:

a. Power-systems-analysis software applications must have analytical capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 3002 series standards.
b. Computer software application must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.
c. Computer software application must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.

2. Analysis Standards:

a. Short-Circuit Current Analysis: In accordance with IEEE 3002.3.
b. Device Coordination Analysis: In accordance with IEEE 3004.3 and IEEE 3004.5.
c. Arc-Flash Hazard Analysis: In accordance with IEEE 1584.

3. Capable of printing arc-flash hazard warnings for equipment on vinyl, weather- and UV-resistant, pressure-sensitive adhesive labels complying with NFPA 70E.

a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard study:

1) Equipment designation.
2) Nominal voltage.
3) Protection boundaries.

a) Arc-flash boundary.
b) Restricted approach boundary.

c) Limited approach boundary.

4) Arc-flash PPE category.
5) Required minimum arc rating of PPE in Cal/cm squared.
6) Available incident energy.
7) Working distance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Collect and analyze data for power system studies.

1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Owner's attention.
2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
3. Gather and tabulate required input data to support power system studies. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 3002 series standards as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

a. Product data for the Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
b. Electrical power utility impedance at service.
c. Power sources and ties.
d. Short-circuit current at each system bus (three phase and line to ground).
e. Full-load current of loads.
f. Voltage level at each bus.
g. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
h. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
i. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
j. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
k. Maximum demands from service meters.
l. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
m. Low-voltage cable sizes, lengths, number, conductor material, and conduit

material (magnetic or nonmagnetic).
n. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
o. Derating factors.

3.2 PREPARATION

A. Preparation of Data for Short-Circuit Study:

1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Owner's attention.
2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
3. Prepare one-line diagram of modeled power system, showing the following:

a. Protective device designations and ampere ratings.
b. Conductor types, sizes, and lengths.
c. Transformer kVA and voltage ratings.
d. Motor and generator designations and kVA ratings.
e. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
f. Derating factors and environmental conditions.
g. Revisions to electrical equipment required by study.

B. Preparation of Data for Overcurrent Protective Device Coordination Study:

1. Prepare data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, indicating the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current

transformer ratio for overcurrent relays.

j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.

k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

2. Examine the Project's overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

3. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

C. Preparation of Data for Arc-Flash Hazard Study:

1. Assemble data from short-circuit study and overcurrent protective device coordination study.

2. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.3 SHORT-CIRCUIT STUDY

A. Base study on device characteristics supplied by device manufacturer.

B. Extent of electrical power system to be studied is indicated on Drawings.

C. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

E. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement to address asymmetrical requirements of interrupting equipment.

F. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas

as defined for three-phase bolted fault short-circuit study.

G. Include in report identification of protective device applied outside its capacity.

3.4 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

A. Base study on device characteristics supplied by device manufacturer.

B. Extent of electrical power system to be studied is indicated on Drawings.

C. Begin analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

E. Transformer Primary Overcurrent Protective Devices:

1. Device must not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads in accordance with IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings must protect transformers in accordance with IEEE C57.12.00, for fault currents.

F. Motor Protection:

1. Select protection for low-voltage motors in accordance with IEEE 3004.8 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V in accordance with IEEE 620.

G. Conductor Protection: Protect cables against damage from fault currents in accordance with ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 3004.7. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

H. Generator Protection: Select protection in accordance with manufacturer's published instructions and IEEE C37.102.

I. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement, to address asymmetrical requirements of interrupting equipment.

J. Include coordination of ground-fault protection devices.

K. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Application of series-rated devices must be recertified, complying with requirements in NFPA 70.
4. Include in report identification of protective device applied outside its capacity.

3.5 ARC-FLASH HAZARD STUDY

A. Comply with NFPA 70E, including Annex D, for arc-flash hazard study.

B. Preparatory Studies: Obtain short-circuit study and overcurrent protective device coordination study results prior to starting arc-flash hazard study.

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.
4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.

D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations.

F. Calculate limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations

must account for changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).

H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:

1. When circuit breaker is in separate enclosure.
2. When line terminals of circuit breaker are separate from work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.6 POWER SYSTEM STUDY REPORTS

A. Preparation of Power System Study Reports: Prepare and submit the following:

1. Short-Circuit Study Report Contents:

a. Executive summary of study findings.
b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
c. One-line diagram of modeled power system, showing the following:

1) Protective device designations and ampere ratings.
2) Conductor types, sizes, and lengths.
3) Transformer kVA and voltage ratings.
4) Motor and generator designations and kVA ratings.
5) Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
6) Derating factors and environmental conditions.
7) Revisions to electrical equipment required by study.

d. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.
e. Short-Circuit Study Input Data:

1) One-line diagram of system being studied.
2) Power sources available.
3) Manufacturer, model, and interrupting rating of protective devices.
4) Conductors.

5) Transformer data.

f. Protective Device Evaluation:

1) Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2) Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3) For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4) For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5) Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

g. Short-Circuit Study Output Reports:

1) Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.
b) Calculated fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) Equivalent impedance.

2) Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.
b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) Calculated asymmetrical fault currents based on fault-point X/R ratio; based on calculated symmetrical value multiplied by 1.6; and based on calculated symmetrical value multiplied by 2.7.

3) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.
b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.

d) No AC Decrement (NACD) ratio.
e) Equivalent impedance.
f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

2. Overcurrent Protection Device Coordination Study Report Contents:

a. Executive summary of study findings.
b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
c. One-line diagram of modeled power system, showing the following:

1) Protective device designations and ampere ratings.
2) Conductor types, sizes, and lengths.
3) Transformer kVA and voltage ratings.
4) Motor and generator designations and kVA ratings.
5) Switchgear, switchboard, motor-control center, and panelboard designations.
6) Revisions to electrical equipment required by study.

d. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.

1) Phase and Ground Relays:

a) Device tag.
b) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
c) Recommendations on improved relaying systems, if applicable.

2) Circuit Breakers:

a) Adjustable pickups and time delays (long time, short time, and ground).
b) Adjustable time-current characteristic.
c) Adjustable instantaneous pickup.
d) Recommendations on improved trip systems, if applicable.

3) Fuses: Show current rating, voltage, and class.

e. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1) Device tag and title, one-line diagram with legend identifying portion of system covered.
2) Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3) Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4) Plot the following listed characteristic curves, as applicable:

    a) Power utility's overcurrent protective device.
    b) Medium-voltage equipment overcurrent relays.
    c) Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d) Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e) Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f) Cables and conductors damage curves.
    g) Ground-fault protective devices.
    h) Motor-starting characteristics and motor damage points.
    i) Generator short-circuit decrement curve and generator damage point.
    j) Largest feeder circuit breaker in each motor-control center and panelboard.

5) Maintain selectivity for tripping currents caused by overloads.
6) Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
7) Provide adequate time margins between device characteristics such that selective operation is achieved.
8) Comments and recommendations for system improvements.

3. Arc-Flash Hazard Study Report Contents:

a. Executive summary of study findings.
b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
c. One-line diagram, showing the following:

    1) Protective device designations and ampere ratings.
    2) Conductor types, sizes, and lengths.
    3) Transformer kVA and voltage ratings, including derating factors and environmental conditions.
    4) Motor and generator designations and kVA ratings.
    5) Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

d. Short-circuit study output data.
e. Overcurrent protective device coordination study report contents.

f. Arc-Flash Study Output Reports:

1) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:

a) Voltage.
b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) No AC Decrement (NACD) ratio.
e) Equivalent impedance.
f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

g. Incident Energy and Flash Protection Boundary Calculations:

1) Arcing fault magnitude.
2) Protective device clearing time.
3) Duration of arc.
4) Arc-flash boundary.
5) Restricted approach boundary.
6) Limited approach boundary.
7) Working distance.
8) Incident energy.
9) Hazard risk category.
10) Recommendations for arc-flash energy reduction.

h. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

3.7 FIELD ADJUSTMENT FOR DEVICE COORDINATION

A. Adjust relay and protective device settings in accordance with recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting must be by qualified low-voltage electrical testing and inspecting agency.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

3.8 WARNING LABELING OF ARC-FLASH HAZARDS

A. Apply arc-flash label on front cover of each section of equipment for each equipment included in study, including each piece of equipment listed below:

1. Switchboards.
2. DC Power Blocks

B. Base arc-flash label data on highest values calculated at each location.

C. Machine print warning labels with no handwritten or field-applied markings.

D. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

E. Indicate on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

END OF SECTION 26 05 73

SECTION 26 24 13 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600V and less
2. Disconnecting and overcurrent protective devices
3. Identification
4. Accessory components and features.

1.2 ACTION SUBMITTALS

A. Product Data For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Delegated Design Submittal:

1. For arc-flash hazard analysis.
2. For arc-flash labels:

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. Include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Accredited by NETA.

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation in accordance with NECA 400.

1.7 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are complete and dry.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 110 deg F (40 deg C).
b. Altitude: Not exceeding 6600 feet (2000 m).

1.8 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete Spec

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 SWITCHBOARDS

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

1. ABB Electrification Installations Products
2. Eaton
3. Siemens Industry, Inc., Energy Management Division
4. Square D; Schneider Electric USA

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.

2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Nominal System Voltage: 480Y/277 V.

J. Main-Bus Continuous: Refer to Drawings.

K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

L. Outdoor Enclosures: Type 3R.

1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
2. Enclosure: Downward, rearward sloping roof; for each section, with provisions for padlocking.
3. Doors: Personnel door at each end of aisle, minimum width of 30 inch; opening outwards; with panic hardware and provisions for cylinder lock. At least one door must be sized to permit largest single switchboard section to pass through without disassembling doors, hinges, or switchboard section.
4. Power for Space Heaters and Ventilation: Include control-power transformer, with spare capacity of 25 percent, within switchboard. Supply voltage must be 120 V(ac).

M. Barriers: Between adjacent switchboard sections.

N. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

O. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

R. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from front of switchboard.
2. Phase- and Neutral-Bus Material:

    a. Hard-drawn copper of 98 percent conductivity.

3. Copper feeder circuit-breaker line connections.
4. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Neutral Buses: 100 percent of ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

S. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB) for circuit breaker frame size less than 1000 amps: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Frame size 200 amps to 800 amps: Circuit breakers with 200A frame and greater shall be electronic trip type with a solid state trip unit with interchangeable rating plug
2. 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 adjustments

3. Frame size below 200A: 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 100 A and larger
4. 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.
5. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
6. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
7. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

B. Circuit breaker frame size 1000 amps and above shall be insulated-case circuit breaker (ICCB):

1. 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current
2. Draw out circuit-breaker mounting.
3. Two-step, stored-energy closing. Fully electrical operated
4. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings

a. Instantaneous trip.
b. Long- and short-time pickup and delay adjustments.
c. Ground-fault pickup level, time delay, and I2t response.

5. Communication Capability: Integral communication module.
6. Control Voltage: 120-V ac.
7. Control Voltage Power Source: Transformer, factory installed in switchboard or external power source as indicated.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with manufacturer's instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards in accordance with NECA 400.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's published instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage in accordance with manufacturer's

published instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect performance of equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Install switchboards and accessories according to NECA 400.

C. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness.

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

E. 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.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.

B. Support and secure conductors within switchboard in accordance with NFPA 70.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Service Equipment Label: Labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections

B. Tests and Inspections:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment in accordance with NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and

malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Coordination Studies."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature in accordance with manufacturer's published instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 26 24 13

SECTION 26 25 00 – BUSWAY-LOW-VOLTAGE

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install the busway system including all necessary fittings, hangers and accessories as specified herein and as shown on the contract drawings.

1.2 REFERENCES

A. The low voltage busway and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards of ANSI and NEMA:

B. NEMA BU.1

C. ANSI/UL 857

D. CSA

1.3 ACTION SUBMITTALS

A. Product Data for each busway, components and accessories.

1. Master drawing index
2. Isometric drawing of each busway run
3. Component list
4. Busway ratings including:

    a. Short-circuit rating
    b. Voltage
    c. Continuous current

5. Major component ratings including:

    a. Voltage
    b. Continuous current
    c. Interrupting ratings

6. Cable terminal sizes
7. Product data sheets

1.4 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.5 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.6 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

1.7 EXTRA PRODUCTS

A. Spare parts shall be furnished for each rating of busway, consisting of:

1. One set of joint covers for each busway

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton
2. Square D; Schneider Electric USA
3. Siemens Industry, Inc., Energy Management Division

2.2 RATINGS

A. The busway shall be voltage and current ratings as indicated on the contract drawings.

1. 3-phase, 4-wire with 100% neutral

B. The busway shall have a minimum of 6-cycle short-circuit rating of 85 kA RMS symmetrical for ratings through 800 Amp, 100 kA RMS symmetrical for ratings through 1350 Amp, 125 kA RMS symmetrical for ratings through 1600 Amp, 150 kA RMS symmetrical ratings through 2500 Amp, and 200 kA RMS symmetrical for ratings through 5000 Amp.

2.3 BUS

A. The busway and associated fittings shall consist of copper conductors totally enclosed in a 2-piece extruded aluminum housing. Fittings – (elbows, tees, flanges, etc.) shall be identical for use with both the plug-in and feeder types of busway. The busway shall be capable of being mounted flat-wise, edgewise, or vertically without derating. The busway shall consist of standard 10-foot sections with special sections and fittings provided to suit the installation. Horizontal runs shall be suitable for hanging on 10-foot maximum centers. Provide one (1) hanger for every ten (10) feet of horizontally mounted duct.

B. Bus bars shall be fabricated from high strength 98% conductivity copper and suitably plated at all electrical contact surfaces.

C. Bus bars shall be insulated over their entire length, except at joints and contact surfaces, with a UL listed insulating material consisting of a thermo set epoxy applied by fluidized bed process. Tape or heat-shrink sleeve insulation, or any other method of insulation, which can allow air-gaps or insulation breakdown, shall not be acceptable.

D. The busway shall be capable of carrying rated current continuously without exceeding a temperature rise of 55 degrees C based on a 40 degrees C ambient.

E. Each busway section shall be furnished complete with joint hardware and covers. The busway joints shall be a single-bolt, non-rotating, removable bridge design. All bridge joints shall be furnished with torque-indicating double head joint bolts and Belleville washers. The bridge joint shall utilize a captive nut retainer on the opposite side of the torque-indicating bolt. The bridge joint design shall ensure proper installation without the use of a torque wrench and provide visual indication that the joint has been tightened to the proper torque value. Each busway joint shall allow for a minimum length adjustment of +/- 0.5 inches. De-energization of busway shall not be required for safe testing of joint tightness.

2.4 HOUSING

A. The busway housing shall be a 2-piece design fabricated from extruded aluminum. The 2-piece housing shall be bolted together, along the bottom flange, using grade 5, 1/4x20 zinc-plated fasteners on 3-inch centers for maximum mechanical strength. The busway enclosure finish shall be ANSI 61 gray baked epoxy powder paint applied by an electrostatic process.

B. Outdoor feeder busway housing shall be identical to indoor feeder busway housings, and shall be UL listed for outdoor use. Busway shall be completely weatherized at the factory, and designed such that only caulking of protective joint covers are required for outdoor application.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

B. The manufacturer shall provide three (3) certified copies of factory test reports.

3.2 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer’s recommendations and the contract drawings.

END OF SECTION 26 25 00

SECTION 26 27 13 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Section includes equipment for electricity metering by utility company.

B. Related Requirements:

1. Section 262413 "Switchboards" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.

a. Comply with requirements of utility providing electrical power services.
b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated

B. Shop Drawings: Dimensioned plans and sections or elevation layouts and wiring diagrams.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data. For electricity-metering equipment to include in emergency, 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.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

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. Modular Meter Center: Factory-coordinated assembly of a main service disconnect device, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.

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

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Siemens Energy & Automation, Inc.
    d. Square D; a brand of Schneider Electric.

2. Comply with requirements of utility company for meter center.
3. Phase and Ground Buses:

    a. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Comply with equipment installation requirements in NECA 1.

C. Install equipment for utility company metering. 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.

D. Install modular meter center according to NECA 400 switchboard installation requirements.

E. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

F. Install panelboards and accessories according to NEMA PB 1.1.

1. Mount plumb and rigid without distortion of box

END OF SECTION 26 27 13

SECTION 26 36 00 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Molded-case-type automatic transfer switches.
2. Transfer switch accessories.

1.2 REFERENCES

A. The automatic transfer switches and bypass isolation automatic transfer switches shall be designed, manufactured and tested in accordance with the following latest applicable standards:

1. UL 1008: Standard for Safety - Transfer Switch Equipment
2. CSA C22.2 No. 178: Automatic Transfer Switches
3. UL 991: Standard for Tests for Safety-Related Controls Employing Solid-State Devices
4. NFPA 70: National Electrical Code
5. NFPA 110: Emergency and Standby Power Systems
6. NEMA ICS 10: Electromechanical AC Transfer Switch Equipment
7. IEEE 446: Recommended Practice for Emergency and Standby Power Systems

1.3 ACTION SUBMITTALS

A. Product Data:

1. Molded-case-type automatic transfer switches.
2. Transfer switch accessories.

B. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.

3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member company of NETA.

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

1.7 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.8 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Equipment being stored prior to installation shall be maintained in a clean and dry condition. If stored outdoors, indoor equipment shall be covered and heated, and outdoor equipment shall be heated.

1.9 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

PART 2 - PRODUCTS

2.1 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

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

1. ABB Electrification Installations Products
2. Cummins Power Generation
3. Eaton
4. Kohler Power Systems

B. Voltage and amperage ratings shall be as indicated on the drawings.

C. Transfer switches shall be UL 1008 listed for application in their intended enclosures at 100% of continuous ampere rating and shall meet or exceed UL 1008 endurance test criteria to include rate of operation and number of operation cycles.

1. The transfer switch shall be designed and intended for switching the load connection between two power sources.
2. The transfer switch shall include electrical and mechanical interlocks to prevent unintentional paralleling of the power sources.
3. Transfer switch shall be of double throw construction and include power switches and/or circuit breakers in a draw-out configuration, with high-endurance characteristics capable of no-load and full-load interruptions at rated current equal to or exceeding UL 1008 endurance ratings.
4. Power switches/circuit breakers shall include an electrical operator with a reliable two-step stored energy mechanism to charge the closing springs. The closing springs shall be capable of being charged electrically or manually. Closing of the main contacts shall automatically charge the opening springs to ensure quick-

break operation. After closing the main contacts, the closing springs shall be capable of being re-charged.

5. Front access to all power switch/circuit breaker secondary connection points shall be provided for ease of troubleshooting and connection to external field connections.
6. The transfer switch shall include a mechanical coupling to facilitate completion of an open in-phase transition such that any inrush current is equal to or less than normal starting current for inductive loads.
7. The transfer switch main contacts shall be of silver composition, electrically operated and mechanically held in position. Inspection of the main contacts shall be possible from the front of the transfer switch without major disassembly.
8. The transfer switch shall include removable arc chutes, housed within an arc chamber constructed of high-dielectric high-strength material, that are mounted over each set of main contacts. Arc chutes shall be constructed of metal plates and a baffle cover designed to extinguish an electrical arc and protect the main contacts. An insulating channel shield shall be mounted above each power switch/circuit breaker to redirect flash from the arc chutes away from the enclosure front. A steel, dead-front panel shall be mounted at the front of each power switch/circuit breaker to provide a physical barrier when the front door is open.
9. The transfer switch shall include pushbutton controls, mounted directly on the power switch/circuit breaker, to perform manual operation with an electrical load connected.
10. The transfer switch shall provide colored mechanical indication of main contact position (open or closed), mounted directly on the power switch/circuit breaker, for source 1 and source 2.
11. The transfer switch shall provide colored mechanical indication of the charge state (charged, discharged), mounted directly on the power switch/circuit breaker, for source 1 and source 2.
12. The transfer switch shall be furnished with tin-plated copper bus bars. All hardware used shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers to the maximum extent possible.
13. The primary means of insulation and isolation of bus shall be by air gap. Minimal use of insulating material in addition to air gap shall be provided.
14. A copper ground bus shall be furnished firmly secured to the enclosure structure.
15. Control wire shall be type SIS and wire bundles shall be secured to the assembly with nylon ties, pre-punched lances or anchors. All current transformer secondary leads shall first be connected to shorting terminal blocks with shorting screws. Control wire shall be marked with an origin and destination over the entire length of the wire using a cured ink process to the maximum extent possible. Where ink marking is not possible, printed sleeve wire markers at each end of control wire shall be provided.
16. Mechanical type lugs shall be provided for all source 1, source 2, and load terminations suitable for copper cable.

D. Transfer switches shall be open transition (break-before-make), and provide a time delay in the load disconnect (“neutral”) position adjustable from 0 to 600 seconds that will permit a delayed transition, and provide an in-phase monitor that will permit an in-phase transition between two live sources that have a phase angle difference of +/- 8

degrees or less (no generator sources) and +/- 5 degrees or less (1-2 generator sources). In the event that the sources do not synchronize to complete an in-phase transition within a time delay period adjustable from 1 to 60 minutes, the transfer switch shall be capable of defaulting to a delayed transition adjustable from 0 to 600 seconds or a load voltage decay transition adjustable from 2 to 30% of nominal voltage.

E. The transfer switch shall include a means of deriving control power for electrical operation. Control power transformers shall be multi-tap for ease of voltage adjustment in the field. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

F. Transfer switches requiring a switched neutral shall include a fully-rated fourth pole that is identical to the other power poles. Switched neutral poles which are add-on, overlap, or not capable of breaking full rated load current are not acceptable.

G. Transfer switches requiring a solid neutral shall include a fully rated, solid neutral plate.

H. For safety and serviceability, steel barriers shall be provided to the maximum extent possible segregating the source 1, source 2, and load connections from the electrical control components including the automatic controller, control power transformer, relays, user controls, and indication lights. Together, the steel barriers and enclosure front door shall form a control compartment that is isolated from the cable/bus compartment.

I. When the transfer switch is equipped with a draw-out cassette mechanism, it shall include rear shutters that automatically close/open when the power switch/circuit breaker is racked out/in providing isolation from the power bus.

2.2 ENCLOSURE

A. The transfer switch shall be provided in a free-standing NEMA 3R steel enclosure suitable for use in environments indicated by the drawings.

B. The transfer switch shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Cable/bus compartment access shall be provided by rear covers fabricated in two (2) pieces for ease of handling and mounted using captive hardware.

C. Provide a separate, front-accessible vertical section for cable termination.

D. The elevation of cable termination locations within the enclosure shall be: Source 1 bottom, Source 2 bottom, and Load bottom.

E. The enclosure shall provide behind-the-door access to each power switch/circuit breaker to perform the following: lever between the connect/isolate for test/disconnect/removed positions, lock-out/tag-out the lever mechanism, manually operate or view status of the charging system, manually close/open the main contacts via pushbutton, close/lock or unlock/open pushbutton cover plate, adjust trip unit

settings, examine accessory and trip unit status, read the device nameplate.

F. NEMA 1, and 3R enclosures shall be constructed of stainless-steel with a light gray ANSI 61 finish.

G. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor at the anchor mount points shown on the as-built drawings.

2.3 MICROPROCESSOR CONTROLLER LOGIC

A. The transfer switch microprocessor controller logic shall be an automatic controller. Operation of the transfer switch and monitoring of both sources shall be managed by the controller. The controller shall be hardened against transient voltages.

B. The automatic transfer switch controller shall meet or exceed the following standards:

1. IEC 61000-4-2 - EMC Testing and Measurement Techniques - Electrostatic Discharge Immunity Test
2. IEC 61000-4-3 - EMC Testing and Measurement Techniques - Radio-frequency, Electromagnetic Field Immunity Test
3. IEC 61000-4-4 - EMC Testing and Measurement Techniques - Electrical Fast Transient/Burst Immunity Test
4. IEC 61000-4-5 - EMC Testing and Measurement Techniques - Surge Immunity Test
5. IEC 61000-4-6 - EMC Testing and Measurement Techniques - Immunity to Conducted Disturbances, Induced by Radio-frequency Fields
6. IEC 61000-4-11 - EMC Testing and Measurement Techniques - Voltage Dips, Short Interrupts and Voltage Variations Immunity Tests
7. CISPR11, Class B - Industrial, Scientific and Medical Radio-frequency Equipment - Electromagnetic Disturbance Characteristics - Limits and Methods of Measurement
8. FCC Part 15, Subpart B, Class B

C. The controller shall have an operating temperature range from -20 to +70 degrees C (-4 to +158 degrees F) and a storage temperature range from -30 to +85 degrees C (-22 to +185 degrees F).

D. The controller shall be capable of accepting 120Vac derived from source 1 and source 2.

2.4 CONTROLLER DISPLAY AND KEYPAD

A. The microprocessor-based controller faceplate shall be UV resistant and include a 4.3-inch, color TFT (480x272) backlit display. The controller shall be capable of displaying transfer switch status, parameters, setpoints, and diagnostic data. Abbreviations or codes shall be limited for intuitive operation. All setpoint parameters shall be password protected.

B. The microprocessor-based controller shall include one (1) unit status LED (3mm) and a mimic power bus consisting of six (6) LED's (3mm) for indicating the following:

1. Availability status of Source 1
2. Availability status of Source 2
3. Connection status of Load to Source 1
4. Connection status of Load to Source 2
5. Preferred status of Source 1
6. Preferred status of Source 2

C. The controller keypad shall include the following pushbutton controls:

1. ENGINE TEST, for use with a generator source.
2. LEFT, RIGHT, UP, DOWN, and ENTER, for ease of navigation and programming
3. HELP/LAMP TEST, for operator assistance and diagnostics
4. BYPASS TIMER, to bypass time delay countdown

D. The controller shall display on the main overview screen:

1. voltage and frequency - source 1, source 2, and load
2. status condition based on setpoints - source 1 and source 2
3. time and date
4. electric current - load

E. The controller shall display the voltage dropout and pickup setpoints, for source 1 and source 2, in volts and as a percentage of nominal voltage.

F. The controller shall display the frequency dropout and pickup setpoints, for source 1 and source 2, in hertz and as a percentage of nominal frequency.

2.5 CONTROLLER VOLTAGE AND FREQUENCY MONITORING

A. The controller shall monitor voltage (Vab, Vbc, Vca) and frequency (Hz) for source 1, source 2, and load.

B. The controller shall have a voltage range of 0-720 Vrms with an accuracy of +/- 1%. Nominal voltage shall be adjustable in 1 volt increments from 120 to 600Vac. The number of voltage phases shall be adjustable as 1 or 3.

C. The controller shall have a frequency range of 40-80 Hz with an accuracy of +/- 0.2 Hz. Nominal frequency shall be adjustable as 50 or 60Hz.

D. The controller shall include a phase sequence check for source 1 and source 2, adjustable to OFF, ABC, or CBA.

E. Voltage and frequency dropout and pickup setpoints, for source 1 and source 2, shall be adjustable as a percentage of nominal per the table below. Pickup and dropout setpoints for overvoltage, underfrequency, overfrequency, and voltage unbalance / phase loss shall be capable of being disabled.

Setpoint	Sources	Dropout	Pickup
Undervoltage	Source1 and 2	70 – 97%	(DO + 2%) to 99%
Overvoltage	Source 1 and 2	105 – 120%	103% to (DO – 2%)
Underfrequency	Source 1 and 2	90 – 97%	(DO + 1Hz) to 99%
Overfrequency	Source 1 and 2	103 – 110%	101% to (DO – 1Hz)
Voltage Unbalance	Source 1 and 2	5 – 20%	3% to (DO – 2%)
Voltage Unbalance Phase Loss (with negative sequence detection)	Source 1 and 2	20 - 60%	18% to (DO – 2%)

F. The controller shall include an algorithm that is capable of detecting a voltage unbalance / phase loss condition at either power source when the power source is unloaded and regenerated, or phantom voltage is present. Once detected, the algorithm shall be capable of preventing a load transfer into a regenerated voltage condition.

G. A setpoint shall be provided for configuring a “preferred source”, adjustable to [none, source 1, source 2, external]. The controller shall seek connection of the load to the preferred source (when it is available). The controller shall also be capable of accepting an external dry contact for remotely configuring source 1 or source 2 as the preferred source.

2.6 CONTROLLER POWER METERING

A. In addition to voltage and frequency sensing in item 2.4, the controller shall provide power metering. The following electrical parameters shall be measured and viewable from the controller display. Terminal connections for current transformer wiring shall be provided.

1. Load Current (Ia, Ib, Ic)
2. Load Real Power (kW)

2.7 CONTROLLER TIME DELAYS

A. A time delay shall be provided for transfer from source 1 to source 2, adjustable from 0 to 166 minutes (0-9999 seconds). A “commit to transfer” feature shall be provided, adjustable as on/off, that is applicable during countdown of the time delay.

B. A time delay shall be provided for retransfer from source 2 to source 1, adjustable from 0 to 166 minutes (0-9999 seconds).

C. A time delay shall be provided for actuation of an engine 1 start signal, adjustable from 0 to 120 seconds, for overriding momentary power fluctuations.

D. A time delay shall be provided for actuation of an engine 2 start signal, adjustable from

0 to 120 seconds, for overriding momentary power fluctuations.

E. A time delay shall be provided allowing the load connection to remain in the “neutral position” (disconnected from source 1 and source 2), adjustable from 0 to 600 seconds.

F. A time delay shall be provided that allows the generator to run unloaded, adjustable from 0 to 166 minutes (0-9999 seconds), for cool-off prior to shut down.

G. A time delay shall be provided to postpone the generator source from being declared unavailable, adjustable from 0 to 6 seconds, for overriding momentary power fluctuations.

H. A time delay shall be provided for actuation of a pre-transfer signal, adjustable from 0 to 120 seconds.

I. A time delay shall be provided for actuation of a post-transfer signal, adjustable from 0 to 120 seconds.

J. A time delay shall be provided to allow synchronization of sources, adjustable from 0 to 60 minutes (0 to 600 seconds), for use with a closed transition or in-phase transition transfer. During synchronization, the phase angle difference between sources shall appear on the controller display.

K. A time delay shall be provided for voltage unbalance and voltage phase loss, adjustable from 10 to 30 seconds.

L. A time delay shall be provided that disconnects the load connection from the preferred source when the preferred source becomes unavailable, adjustable as off, 0-10 seconds, and reconnects the load connection to the preferred source when the preferred source becomes available, adjustable as 0-60 seconds.

M. A time delay shall be provided that disconnects the load connection from the non-preferred source when the non-preferred source becomes unavailable, adjustable as off, 0-10 seconds, and reconnects the load connection to the non-preferred source when the non-preferred source becomes available, adjustable as 0-60 seconds.

N. All time delays shall be programmable, using the controller keypad, without the use of special tools. Time delay countdowns shall appear on the controller display

2.8 CONTROLLER ADDITIONAL FEATURES

A. A setpoint shall be provided for entering a four-digit password, adjustable from 0000-9999, for controlling user access to programmable time delays, inputs, outputs, and other system settings.

B. A setpoint shall be provided allowing the load connection to remain in the “neutral position” (disconnected from source 1 and source 2) until the load voltage decays below a percentage of the nominal voltage, adjustable from 2 -30%, for use with

inductive loads.

C. A setpoint shall be provided for configuring retransfer operation mode, adjustable as automatic, manual, external. The controller shall also be capable of accepting an external dry contact to remotely configure the retransfer operation as manual or automatic.

D. A setpoint shall be provided to change date, time, and enable daylight saving time (DST).

E. A setpoint shall be provided for setting the number of generator sources, adjustable as 0, 1, or 2.

F. A setpoint shall be provided for configuring closed transition operation, adjustable as disabled, enabled with default to alarm, enabled with default to open transition. When closed transition is enabled, the controller shall be capable of defaulting to an open transition when the source synchronization time delay expires or defaulting to an alarm condition.

G. A setpoint shall be provided for configuring a voltage difference range between sources for closed transition, adjustable from 1 to 5% of nominal.

H. A setpoint shall be provided for configuring a frequency difference range between sources for closed transition, adjustable from 0 to 0.3 hertz nominal.

I. A setpoint shall be provided for configuring in-phase transition operation, adjustable as disabled, enabled with default to alarm, enabled with default to open transition. When in-phase transition is enabled, the controller shall be capable of defaulting to an open transition when the source synchronization time delay expires or defaulting to an alarm condition.

J. A setpoint shall be provided for configuring a frequency difference range between sources for in-phase transition, adjustable from 0 to 3 hertz nominal.

2.9 CONTROLLER PLANT EXERCISER

A. The controller shall provide two (2) independent, programmable engine plant exercisers.

B. Each engine plant exerciser shall provide the following user programmable setpoints that are only applicable during an engine test:

1. Test schedule, adjustable to [disabled, daily, 7-day interval, 14-day interval, 28-day interval, specific calendar dates]. Up to twelve (12) specific calendar dates, month (1-12) and day (1-31).
2. Start time in hours and minutes, AM or PM.
3. Day of the week (Sun, Mon, Tues, Wed, Thurs, Fri, Sat)
4. Test mode, adjustable to disabled, no load transfer, loaded transfer.
5. Run time, adjustable from 0 to 600 minutes (0 to 6000 seconds).

6. Time delay for transfer from source 1 to source 2, adjustable from 0 to 166 minutes (0-9999 seconds).
7. Time delay for retransfer from source 2 to source 1, adjustable from 0 to 166 minutes (0-9999 seconds).
8. Time delay that allows the generator to run unloaded, adjustable from 0 to 166 minutes (0-9999 seconds), for cool-off prior to shut down.

C. A failsafe shall initiate an automatic retransfer to source 1 if source 2 should fail during an engine test.

2.10 CONTROLLER INPUTS

A. The controller shall include two (2) dedicated inputs for monitoring the position of the main contacts (source 1 and source 2).

B. The controller shall include four (4) programmable control inputs that provide 10mA @ 50-Vdc. Each input shall be capable of accepting an external dry contact and being configured for one of the following functions:

1. Monitor mode – disable automatic operation of the controller while continuing to display status information and allow set point programming.
2. Bypass timers – bypass a time delay countdown
3. Lockout – disable automatic operation of the controller and lock-out an integral overcurrent protection device (circuit breaker).
4. Manual retransfer - remotely initiate a retransfer from source 2 to source 1.
5. Enable Manual retransfer – remotely configure the retransfer operation as manual or automatic.
6. Secondary in – receive a signal from a primary controller to initiate engine start of one or two generator sources. For use in 3-source systems comprised of a single utility source and two generator sources.
7. Remote engine test – remotely initiate an engine test in accordance with programmed plant engine exerciser setpoints.
8. Preferred source selection – remotely configure source 1 or source 2 as the preferred source.
9. Go to emergency - initiate a transfer of the load to the emergency source (source 2). A failsafe shall initiate an automatic retransfer to source 1 if source 2 should fail.
10. Emergency inhibit/shed – remotely inhibit transfer of the load to the emergency source (source 2) or shed the load from the emergency source (source 2) if already connected.
11. Go to neutral – remotely disconnect the load connection from source 1 and source 2.
12. Disabled – performs no predefined function.

2.11 CONTROLLER OUTPUTS

A. The controller shall provide four (4) dedicated Form A relay outputs for controlling the power switch device.

B. The controller shall provide one (1) dedicated Form C relay output for an engine 1 start signal, for use with a second generator source. The contacts shall be rated for 5A @ 250-Vac / 5A @ 30-Vdc.

C. The controller shall provide one (1) dedicated Form C relay output for an engine 2 start signal, for use with a single generator source. The contacts shall be rated for 5A @ 250-Vac / 5A @ 30-Vdc.

D. The controller shall provide one (1) dedicated Form C relay output for Source 1 Available. and the contacts shall be rated for 10A @ 250-Vac / 10A @ 30-Vdc.

E. The controller shall provide one (1) dedicated Form C relay output for Source 2 Available and the contacts shall be rated for 10A @ 250-Vac / 10A @ 30-Vdc.

F. The controller shall provide four (4) programmable Form C relay outputs rated for 10A @ 250-Vac and 10A @ 30-Vdc. Each output shall be capable of being configured for one of the following functions:

1. Status/Alarm

    a. Source 1 available
    b. Source 2 available
    c. Source 1 connected
    d. Source 2 connected
    e. ATS not in automatic mode
    f. General alarm (indication for failure to transfer, mechanical fault, or electrical fault)
    g. ATS in test status
    h. Engine test aborted
    i. Engine cool down in process
    j. Engine 1 start status
    k. Engine 2 start status
    l. Emergency inhibit on

2. Control

    a. Load sequence - used to signal select loads for disconnect prior to transfer and reconnect 0-120 seconds after. Up to 10 loads are reconnected sequentially.
    b. Selective load shed – used to manage low priority loads upon reaching a KW threshold. Dropout and pickup setpoints (kW) are associated with this feature.
    c. Load bank control – used to signal for disconnect of a load bank during a loaded engine test if a transfer to source 2 is imminent.
    d. Pre/post transfer signal
    e. Pre-transfer signal
    f. Post-transfer signal
    g. User remote control

2.12 CONTROLLER DATA LOGGING

A. The controller shall record, store and display a cumulative counter history of the following parameters. Each counter shall have the ability to be reset and indicate the last reset date.

1. Source 1 Available time
2. Source 2 Available time
3. Source 1 Connected time
4. Source 2 Connected time
5. Source 1 Engine Run time
6. Source 2 Engine Run time
7. Tier IV time (source 1 and source 2 available)
8. Load Energized time
9. Number of transfers

B. The controller shall record, store and display up to 100 event summaries that are date/time stamped. Events types shall include the following:

1. Actions of the transfer sequence
2. Alarms
3. Changes to the set points
4. Changes to the time/date
5. Resetting a historical counter
6. Engine run test

C. The controller shall record, store and display up to 350 event details that are date/time stamped. Event details shall include a detailed sequence of operation. Voltage and frequency for source 1, source 2, and the load shall be logged for each event.

D. The controller shall record and store high speed metering data every 20 milliseconds or specific events. Data capture shall include two (2) seconds before and two (2) seconds after an event except during a power failure which will capture four (4) seconds before an event. Oscillographic data shall be stored for 10 events and available for download via USB. Event types shall include:

1. Source unavailability actions that initiate a transfer sequence (undervoltage, overvoltage, underfrequency, overfrequency, etc.)
2. Successful transfers
3. Unsuccessful transfers (power switch device failure to close or open)

2.13 CONTROLLER COMMUNICATION

A. A single USB port shall be externally accessible and provide the following:

1. Download of event history and metering data for detailed analysis
2. Compatible for use with setpoint editor (EASE) configuration tool
3. Upload/download of controller setpoints for commissioning and troubleshooting
4. Upload of controller firmware for field update

B. Serial communication (RS-485) with support for Modbus RTU protocol shall be provided with an integral network termination resistance that can be switched on/off.

2.14 ATS HEALTH

A. The transfer switch controller shall report equipment condition on the local display. The following real-time parametric data shall be provided.

1. Number of open/close operations for the Source 1 and Source 2 main contacts. Percentage of operations performed compared to the UL 1008 endurance test limit. A notification shall be issued when the limit is reached.
2. Total number of load overcurrent events that have occurred with event date/time stamp and duration
3. Total number of Source 1 and Source 2 overvoltage events that have occurred with event date/time stamp, phase, and voltage.
4. Total duration (days/hours/minutes) the transfer switch is under load (electrical current flow).
5. Total number of days that have elapsed since the transfer switch was last exercised and date/time stamp of last exercise.
6. Open/close actuation time of the Source 1 and Source 2 main contacts and the load disconnect time for open in-phase transition.
7. Protection status of integral surge protection device (SPD) installed at Source 1, Source 2 and Load connection.
8. Health status of integral Source 1 and Source 2 circuit breaker.

B. The operator shall have the ability to enable/disable ATS Health.

C. Parametric data shall be viewable locally on the controller display or a third-party power/building management system.

2.15 ACCESSORIES

A. Space heater: Provide a 325KW rated space heater with thermostat.

2.16 WITHSTAND AND CLOSING CURRENT RATINGS

A. Short-circuit

1. The transfer switch shall be UL1008 listed and rated for use in a circuit capable of delivering the short-circuit current shown on the drawings.
2. The transfer switch shall have a short-circuit withstand and closing rating of 4000 KA at 480 volts when protected by a specific circuit breaker.
3. The transfer switch shall have a short-circuit withstand and closing rating of 100 KA at 480 volts for a time duration of 0.05 seconds.

B. Short-time

1. The transfer switch shall be UL1008 listed and rated for use in a circuit capable of delivering the short-time current shown on the drawings.
2. The transfer switch shall have a short-time withstand and closing rating of 85 KA at 480 volts for a time duration of 0.5 seconds.

2.17 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. 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.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for [**emergency**][**legally required**] systems. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

1. Insulation check to ensure the integrity of insulation and continuity of the entire system
2. Visual inspection to ensure that the switch matches the specification requirements and to verify that the fit and finish meet quality standards
3. Mechanical tests to verify that the switch's power sections are free of mechanical hindrances

4. Electrical tests to verify the complete electrical operation of the switch and to set up time delays and voltage sensing settings of the logic

B. The manufacturer shall provide a certified copy of factory test reports.

C. Transfer switch shall include a label indicating order number, catalog number and date

3.2 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings

B. All necessary hardware to secure the assembly in place shall be provided by the contractor

3.3 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section for a period of 5 working days. The manufacturer's representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

3.4 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide a copy of the manufacturer's representative's certification.

3.5 TRAINING

A. The Contractor shall conduct a training session for up to five (5) owner's representatives for two normal workdays at a jobsite location determined by the owner. The training program shall consist of the instruction on the operation of the transfer switch and the major components within the assembly.

3.6 FIELD SERVICE ORGANIZATION

A. The manufacturer of the ATS shall also have a national service organization that is available throughout the contiguous United States and is available on call 24 hours a day, 365 days a year.

END OF SECTION 26 36 00

SECTION 27 15 13 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 6 twisted pair cable.
2. Identification products.

1.2 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

B. EMI: Electromagnetic interference.

C. FTP: Shielded twisted pair.

D. F/FTP: Overall foil screened cable with foil screened twisted pair.

E. F/UTP: Overall foil screened cable with unscreened twisted pair.

F. IDC: Insulation displacement connector.

G. Jack: Also commonly called an "outlet," it is the fixed, female connector.

H. LAN: Local area network.

I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

J. RCDD: Registered Communications Distribution Designer.

K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

M. S/FTP: Overall braid screened cable with foil screened twisted pair.

N. S/UTP: Overall braid screened cable with unscreened twisted pairs.

O. UTP: Unscreened (unshielded) twisted pair.

1.3 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

B. The maximum allowable horizontal cable length is **295 feet**. This maximum allowable length does not include an allowance for the length of **16 feet** to the workstation equipment or in the horizontal cross-connect.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Category 6 twisted pair cable.
2. Identification products.

B. Twisted pair cable testing plan.

C. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, installation supervisor, and field inspector.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Plugs: Ten of each type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Non-Plenum Rated:

a. Type CMR complying with UL 1666.
b. Type CMP or Type CMR in listed plenum or riser communications raceway.

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

A. Category 6 Twisted Pair Cable: Four-pair, balanced -twisted pair cable, with internal

spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250 MHz.

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

1. Belden Inc.
2. CommScope, Inc
3. Mohawk; a division of Belden Networking, Inc.
4. Superior Essex Inc.; subsidiary of LS Corp.

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

1. Lead Content: Less than 300 parts per million.

E. Shielding/Screening: Shielded twisted pairs (FTP).

F. Cable Rating: Riser.

G. Jacket: Blue thermoplastic.

2.4 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

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

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Routing:

1. Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal raceway and cables, except in unfinished spaces.

    a. Comply with requirements for raceways and boxes specified in Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems."

2. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

A. Comply with Section 26 05 432 "Underground Ducts and Raceways Hangers and Supports for Electrical Systems."

B. Drawings indicate general arrangement of pathways and fittings.

3.3 INSTALLATION OF TWISTED PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Do not untwist twisted pair cables more than **1/2 inch** from the point of termination to maintain cable geometry.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced.
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 Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use 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. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches**.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches**.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches**.

3.4 GROUNDING

A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: Class 1.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable Schedule: Install in a prominent location in each power bank. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within **4 inches** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the

following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not 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.

B. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

C. Nonconforming Work:

1. End-to-end cabling will be considered defective if it does not pass tests and inspections.
2. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

D. Collect, assemble, and submit test and inspection reports.

END OF SECTION 27 15 13