PREFACE

PURPOSE OF THIS DOCUMENT

The intent of this document is to disseminate the San Francisco International Airport’s (SFO’s or Airport’s) expectations regarding the information presented to designers, engineers, general contractors and other industry specialists. The material provided in the following sections includes the minimal requirements, general information, design criteria, guide specifications and details for electrical substations & transformers installed at SFO. While this document addresses major areas of concern to SFO, it is not an all-inclusive document.

HOW TO USE THIS DOCUMENT

This document should be used as a resource for the development of project specific design documents including drawings, details and specifications. It is the responsibility of the design, engineering and construction professionals to adhere to all codes and regulations related to the content presented.

SCOPE

This section contains the Standards and Criteria for Electrical Substations & Transformers. Any questions or concerns regarding the items or equals specified must be submitted to the Standards Committee in writing. All final decisions regarding products shall be made at the Airport’s discretion. If the Engineer of Record presents items that are not specified or named equals, they must be brought to the Standards Committee for evaluation of those products.

DRAWING REQUIREMENTS

A. All design disciplines including the architectural/engineering sub-consultants and the trade bid package subcontractors shall prepare documents using Revit in the current version utilized by the Airport in compliance with the Airport’s Building Information Modeling (BIM) Requirements as described in Document 00 73 87: BIM Requirements, unless waived by the Chief Development Officer.

B. When Revit models may not be applicable, (for example, tasks with underground infrastructure beyond a building footprint), Civil 3D may be used to model utilities and applicable infrastructure if approved by the Chief Development Officer.

C. Refer to technical specifications for As-Built requirements.

D. Documents and plans submitted to SFO shall be searchable using PDFs with live text. This includes, but is not limited to, text and symbols. The document shall also provide the capability to turn layers on and off. Any project using legacy documents which may be composed image files shall be converted to live text via Optical Character Recognition (OCR).
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SECTION 26 11 16 – SECONDARY UNIT SUBSTATIONS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:
   1. Primary incoming section.
   2. Transformer.

B. Related Sections include the following:
   1. The specification section entitled “Medium-Voltage Cables” for requirements of terminating cables in incoming section of substation.
   2. The specification section entitled “Overcurrent Protective Device Coordination Study” for short-circuit rating of devices and for setting of overcurrent protective devices.
   3. The specification section entitled “Electrical Power Monitoring and Control” for communication features of power distribution system devices.
   4. The specification section entitled “Medium-Voltage Switchgear” for metering and instrument transformers.
   5. The specification section entitled “Enclosed Bus Assemblies” for busway connections between transformers and secondary distribution equipment.
   6. The specification section entitled “Surge Protection for Low-Voltage Electrical Power Circuits” for transient voltage surge suppressors for low-voltage power, control, and communication equipment that may be located in secondary section.

1.2 DEFINITIONS


1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Dimensioned plans and elevations showing major components and features.
   3. One-line diagram.
   4. List of materials.
   5. Nameplate legends.
   6. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
7. Short-time and short-circuit current ratings of secondary unit substations and components.

8. Ratings of individual protective devices.

C. Qualification Data: For testing agency.

D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in the specification section entitled “Vibration and Seismic Controls for Electrical Systems.” Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. 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.”

2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For secondary unit substations, signed by product manufacturer.

F. Material Test Reports: For secondary unit substations.

G. Factory test reports. Comply with ANSI and IEEE testing standards.

H. Field quality-control test reports. Comply with ANSI and IEEE testing standards.

I. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent SFO approved testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency’s Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.

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

D. Comply with IEEE C2.

E. Comply with IEEE C37.121.

F. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Handle secondary unit substation components according to manufacturer’s written instructions. Use
factory-installed lifting provisions.

1.6 PROJECT CONDITIONS
A. Field Measurements: Indicate measurements on Shop Drawings.

1.7 COORDINATION
A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 – PRODUCTS
2.1 MANUFACTURERS
A. Available Manufacturer: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS
A. Indoor Unit Arrangement: Single assembly.
B. Indoor Unit Arrangement: Separate secondary distribution equipment connected with busway.
C. Enclosure Finish: Factory-applied finish in manufacturer’s standard color, including undersurfaces treated with corrosion-resistant undercoating.

2.3 INCOMING SECTION
A. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations, vacuum breaker, CT’s, PT’s, CPT, metering and surge arresters.
B. Primary Incoming Section: Enclosed Steel, NEMA 250, Type 1.
C. The vacuum breaker shall be operated by a motor charged spring stored energy mechanism. The stored energy mechanism shall be front accessible and will be charged normally by a universal electric motor and by a manual handle.
D. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings.
E. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device.
F. Control-Power Transformers: Dry type, mounted.
G. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four- wire systems: Square D PMCS.
H. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.4 DRY-TYPE TRANSFORMER SECTION
A. Description: IEEE C57.12.01, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.
B. Enclosure: Indoor, ventilated, vacuum-pressure, impregnated type and with insulation system rated
at 220 °C with an 80 °C average winding temperature rise above a maximum ambient temperature of 40 °C.

C. Cooling System: Class AA/FA, air cooled with forced-air rating, complying with IEEE C57.12.01.
   1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
   2. Include mounting provision for fans.

D. Insulation Materials: IEEE C57.12.01, rated 220 °C.

E. Insulation Temperature Rise: 150 °C, maximum rise above 40 °C.

F. Basic Impulse Level: 95 kV.

G. Full-Capacity Voltage Taps: 4 nominal 2.5% taps, 2 above and 2 below rated primary voltage.

H. Impedance: 5.75%.

I. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

J. Windings: Copper

2.5 SECONDARY DISTRIBUTION SECTION

A. Secondary Terminal Compartment: Bus bars mounted on standoff insulators.

B. Network Protectors:
   1. Rated for continuous service in an ambient temperature of up to 40 °C, applied to 3-phase, 4-wire, solidly grounded wye secondary networks. Comply with IEEE C57.12.44.
   2. Protector Operator: Spring-close and stored-energy mechanism, rated to close on a 25,000 RMS symmetrical load.
   3. Control Voltage: Not more than 125 V
   4. Control microprocessor-based, three-phase, tripping relay with features and functions as follows:
      a. Close protector if positive sequence power flows into the network. Adjustable closing range shall be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
      b. Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors shall be adjustable from 0.05 to 5% of continuous-current rating of current transformers within protector.
      c. Trip protector if there is a flow of reverse magnetizing current of its associated transformer.
      d. Field-adjustable relay parameters and watt or watt-var trip values.
   5. Protector shall not open under any fault on network side of protector.
   6. Mechanical interlocks shall prevent racking in and racking out when protector is closed.
   7. Auxiliary contacts shall be remotely tripped and locked out by four-wire remote pilot devices.
8. Network protectors shall have not less than two spare auxiliary dry contacts.

9. Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted main circuit breaker rated for fault current that can be delivered by the network transformers, less one.

2.6 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment. Nameplates and label products are specified in Division 26 sections pertaining to “Identification for Electrical Systems.”

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.

2. Ratios on the rated voltage connection and on tap extreme connections.

3. Polarity and phase relation on the rated voltage connection.

4. No-load loss at rated voltage on the rated voltage connection.

5. Exciting current at rated voltage on the rated voltage connection.

6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.


8. Induced potential.

9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class FA rating,
   a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

C. Factory Witness Tests: All factory tests shall be witnessed by designated Airport staff to guarantee compliance. Notify Airport Staff a minimum of 3 weeks prior to actual test.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of work.

B. Examine roughing-in of conduits and grounding systems to verify the following:
1. Wiring entries comply with layout requirements.

2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Division 26 sections pertaining to “Grounding and Bonding for Electrical Systems” have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

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

3.2 INSTALLATION

A. Install secondary unit substations on concrete bases.

1. Anchor secondary unit substations to concrete bases according to manufacturer’s written instructions, seismic codes at Project, and requirements in Division 26 sections pertaining to “Hangers and Supports for Electrical Systems” and Division 26 sections pertaining to “Vibration and Seismic Controls for Electrical Systems.”

B. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in the specifications section entitled Division 26 sections pertaining to “Identification for Electrical Systems.”

B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 sections pertaining to “Grounding and Bonding for Electrical Systems.”

B. Connect wiring according to Division 26 sections pertaining to “Low-Voltage Electrical Power Conductors and Cables.”

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installations, including connections. Report results in writing.

B. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports.
C. Perform the following field tests and inspections and prepare test reports:
   1. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
   2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
   3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
   4. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
      a. Remove and replace malfunctioning units and retest as specified above.

3.7 FOLLOW-UP SERVICE
   A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than 6 months after Final Acceptance, perform the following voltage monitoring:
      1. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
         a. Adjust transformer taps.
         b. Rebalance loads.
         c. Prepare written request for voltage adjustment by electric utility.
      2. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
   B. Infrared Scanning: Perform as specified in the specification section entitled “Medium-Voltage Switchgear.”

3.8 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain systems. Refer to division 1 sections pertaining to “Demonstration and Training.”

END OF SECTION 26 11 16
SECTION 26 12 19 – PAD MOUNTED LIQUID-FILLED TRANSFORMERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provisions: Applicable provisions of Division 26 sections pertaining to General Requirements become a part of this section as if repeated herein.

B. Related work described elsewhere:
   1. Conduit, raceway and fittings
   2. Low-voltage wire and cable
   3. Medium-voltage cable:

1.2 REFERENCE STANDARDS


C. ANSI C57.12.22 - Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High Voltage Bushings; 2,500 KVA and Smaller: High-Voltage, 34,500 GrdY/19,920 Volts and Below: Low Voltage, 480 Volts and Below-Requirements.


G. IEEE C57.13 - Requirements for Instrument Transformers.

H. ANSI/IEEE 386 - Separable Insulated Connector Systems for Power Distribution Systems – Above 600V.


J. NEMA AB1 - Molded Case Circuit Breakers.

1.3 SUBMITTALS

A. Submit the following for review/approval:
   1. The following information shall be submitted to the Engineer:
      a. Dimension drawing.
      b. Technical certification test.
c. Conduit entry/exit locations.

d. Transformer ratings including:
   1) Voltage
   2) Continuous current
   3) Basic impulse level for equipment over 600 volts
   4) KVA
   5) Impedance

2. Submit one (1) hard copy and one (1) electronic copy of the above information.

B. Submit the following closeout:

   1. The following information shall be submitted for record purposes prior to final payment.
      a. Final as-built drawings and information for items listed in Section 1.04A.
      b. Certified production test reports.
      c. Installation information.
      d. Seismic certification and equipment anchorage details.

   2. Submit one (1) hard copy and one (1) electronic copy of the above information.

1.4 OPERATION AND MAINTENANCE DATA

   A. Submit operation and maintenance data.

   B. Include procedures for sampling and maintaining fluid, cleaning unit, and replacing components.

1.5 QUALITY ASSURANCE

   A. Manufacturer: Competent specializing in distribution transformers with minimum of 5 years documented experience. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

   B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

1.6 REGULATORY REQUIREMENTS

   A. All transformers shall be UL Listed and bear the UL label.

1.7 DELIVERY, STORAGE, AND HANDLING

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

1.8 FIELD MEASUREMENTS

   A. Measure primary and secondary voltages and make appropriate tap adjustments.

PART 2 – PRODUCTS

2.1 MEDIUM-VOLTAGE (12KV) TRANSFORMER

   A. The transformer shall be compartment type. Three-phase, self-cooled for mounting on a pad and shall comply with the latest applicable standards.
B. The average temperature rise of the windings, measured by the resistance method, shall be 65º C, when the transformer is operated at rated KVA output in a 40º ambient. The transformer shall be capable of being operated at rated load in a 30º C average, 40º C maximum ambient, as defined by ANSI C57.12.00 without loss of service life expectancy.

C. Coolant and insulating fluid shall be inhibited mineral oil.

D. The high and low voltage compartments shall be located side by side, separated by a steel barrier. When facing the transformer, the low voltage compartments shall be on the right. Terminal compartments shall be full height, air-filled with individual doors. The high voltage door fastenings shall not be accessible until the low voltage door has been opened.

E. The following accessories shall be provided as standard:
   1. Nameplate in low voltage compartment, 1” upper filter press and filling plug, 1” drain plug, 1” drain valve with sampling device.
   2. Drain plug.
   3. Tap changer, for de-energized operation only, which is externally operable and pad lockable. The front of both compartments shall be removable to allow the transformer to be rolled or skidded into position over conduit stubs. ANSI tank grounding provisions shall be furnished in both compartments.

F. Primary voltage delta. Secondary voltage wye, 4 wire 60Hz with two 2-1/2% full capacity above normal and two 2-1/2% below normal taps. Impedance shall be manufacturer’s standard of 7-1/2%. Basic impulse level of the primary winding shall be 95 KV as specified in ANSI C57.12.00 for comparable KV class.

G. The transformer shall be of sealed-tank construction and of sufficient strength to withstand a pressure of 7 PSI without permanent distortion. The cover shall be welded and the fastenings tamper-resistant. The transformer shall remain effectively sealed for a top oil temperature range of -5° C to 105° C. Cooling panels shall be provided on the back and sides of the tank. Lifting eyes and packing pads shall be provided.

H. Coils shall be wound with copper conductors.

I. Core and coil assembly shall be the five legged core type, using high grade grain-oriented silicon steel laminations carefully annealed after fabrication to restore high magnetic permeability. Magnetic flux is to be kept well below the saturation point.

J. The high voltage terminations and equipment shall be dead front and conform to ANSI C57.12.26.

K. Dead front bushings shall be either universal wells or one piece integrated for use with separable connectors. Bushings shall be externally clamped and front removable.

L. The low voltage bushings shall be molded epoxy, and provided with blade-type spade terminals with NEMA standard hole spacing arranged for vertical take-off. The low voltage neutral shall be an insulated bushing, grounded to the tank by a removable ground strap.

M. Provide a load break, gang operated, liquid immersed switch that is externally operable from the high voltage compartment through the use of a distribution hot-stick.
N. Switch to be 3 position for use on an alternate feed system with feed from the left, off, or feed from the right.

O. Liquid immersed switch shall be rated at 200 Amps.

P. Provide dry-well canister mounted current limiting fuses that are externally replaceable with a distribution hot-stick without opening the transformer tank.

Q. Surge Protection: Provide three 15 KV distribution class lightning arresters for surge protection. Arresters are to be mounted in the high voltage compartment.

R. Accessories:
   1. 1" drain valve with sampling device.
   2. Dial type thermometer.
   4. Pressure vacuum gauge.
   5. Pressure relief valve.
   6. Automatic pressure relief device (self-resealing with indicator).
   7. Mounting provisions for low voltage current transformers and potential transformers.
   8. Busway opening into the low voltage compartment to accommodate Busway.
   9. Molded case main circuit breaker(s) in the low voltage compartment main rated 400 amperes - 2000 amperes maximum rating.
   10. Sudden pressure relay.
   11. Key interlock to high voltage door.
   12. KWH meter socket with hinge cover externally mounted on the side of the low-voltage compartment.
   13. Drain Valve with Sampler
   14. Surge Arrestors
   15. Current Transformer
   17. Connection for incoming cable
   18. Bushing well inserts
   19. Pentahead bolts for compartment doors

S. Testing - Test shall be conducted in accordance with the provisions of ANSI C57.12.90 and shall include, as a minimum, the following tests:
   1. Ratio
   2. Polarity
   3. Phase Rotation
   4. No-load loss
   5. Excitation current
6. Impedance Voltage
7. Load loss
8. Applied potential
9. Induced potential
10. QA Impulse test

2.2 WIRING AND TERMINATIONS
A. Recommended external cable shall be rated 90 °C for encapsulated and 75 °C for ventilated designs. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.

2.3 ENCLOSURE
A. The enclosure shall be made of heavy-gauge steel. All transformers shall be equipped with wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 °C. The core of the transformer shall be grounded to the enclosure.

B. The enclosure construction shall be ventilated, NEMA rated outdoor type, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt. Provide suitable weathershields over ventilation openings.

C. Enclosures shall be finished with ANSI 61 color weather-resistant enamel.

2.4 ACCEPTABLE MANUFACTURERS:
A. Transformers shall be as manufactured by:
   1. Square D
   2. Eaton
   3. Or approved equal

2.5 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 ANSI, IEEE and NEMA standards.
   1. Ratio tests at the rated voltage connection and at all tap connections.
   2. Polarity and phase relation tests on the rated voltage connection.
   3. Applied potential tests.
   4. Induced potential test.
   5. No-load and excitation current at rated voltage on the rated voltage connection.
   6. Impedance Voltage Test
   7. Leak Test
   8. Factory QC Impulse Test
   9. Resistance measurement Test
   10. Test insulating liquid samples in accordance with IEEE C57
PART 3 – INSTALLATION

A. Install equipment according to manufacturer’s recommendations and as shown on drawings.

B. Install safety labels to NEMA 260. Safety label per NEMA.

C. Adjust primary taps so that secondary voltage is within 1% of rated voltage.

D. Field testing shall be performed and meet the ANSI/IEEE C57.12.90 standard. All test reports shall be turned over to SFO contract manager.

E. Furnish and install 3/4” x 10’ copper clad steel ground rods in Christy ground rod boxes. Ground the secondaries and transformer neutral in accordance with Section 250 of the latest National Electric Code.

END OF SECTION 26 12 19
SECTION 26 12 16 – DRY TYPE TRANSFORMERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provisions: Applicable provisions of the specification sections entitled “General Electrical Requirements” and “Basic Materials and Methods” become a part of this section as if repeated herein.

1.2 REFERENCE STANDARDS

A. ANSI C57.12.22 - Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High Voltage Bushings; 2,500 KVA and Smaller: High Voltage, 34,500 GrdY/19,920 Volts and Below: Low Voltage, 480 Volts and Below-Requirements.


D. ANSI C89.1 – Specialty Transformer

E. ANSI C89.2 – Dry Type Transformer for General Applications

F. ANSI Z55.1-1967 – Gray finishes for Industrial Apparatus and Equipment


H. IEEE C57.13 - Requirements for Instrument Transformers.

I. ANSI/IEEE 386 - Separable Insulated Connector Systems for Power Distribution Systems – Above 600V.

1.3 WORK INCLUDED

A. Ventilated dry type transformers, self-cooled, metal enclosed, for indoor use.

1.4 SUBMITTALS

A. Submit the following for review/approval:

1. The following information shall be submitted to the Engineer:
   a. Dimension drawing.
   b. Technical certification test.
   c. Conduit entry/exit locations.
   d. Transformer ratings including:
1) Voltage
2) Continuous current
3) Basic impulse level for equipment over 600 volts
4) KVA
5) Impedance

2. Submit one (1) hard copy and one (1) electronic copy of the above information for review and approval.

B. Submit the following for closeout:

1. The following information shall be submitted for record purposes prior to final payment.
   a. Final as-built drawings and information for items listed in Section 1.3 A.
   b. Certified production test reports.
   c. Installation information.
   d. Seismic certification and equipment anchorage details.

2. Submit one (1) hard copy and one (1) electronic copy of the above information.

1.5 OPERATON AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include procedures and replacing components.

1.6 QUALITY ASSURANCE

A. Manufacturer: Competent specializing in distribution transformers with minimum of 5 years documented experience. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

1.7 REGULATORY REQUIREMENTS

A. All transformers shall be UL Listed and bear the UL label.

1.8 DELIVERY, STORAGE, AND HANDLING

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

1.9 FIELD MEASUREMENTS

A. Measure primary and secondary voltages and make appropriate tap adjustments.

PART 2 – PRODUCTS

2.1 DRY TYPE TRANSFORMER
A. Transformer KVA and voltage rating as shown on plans.

B. Transformer shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy and daily overload requirements as defined in ANSI C57.96.

C. Transformer sound level shall not exceed the following ANSI and NEMA levels for self-cooled ratings of 45 db for 25 to 50 kVA, 50 db for 51 to 150 kVA and 55db for 151 to 300 kVA.

D. It shall be rated for 150° centigrade temperature rise with NEMA class H insulation. All insulation materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D635.

E. Transformer core shall be constructed with high-grade, non-aging, grain oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above highest tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction.

F. The core and coil assembly shall be impregnated with non-hygroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on neoprene rubber vibration-absorbing pads. Provide 1” thick neoprene pads to isolate transformer from floor or platform. Taps shall be two steps above and 4 steps below nominal voltage in 2.5% increments. Windings shall be copper.

G. Transformer shall have a minimum of 9” clearance between transformer ventilation openings and adjacent structure. All transformer connections shall be made with flexible metallic conduit.

H. Provide engraved lamacoid nameplate for each transformer.

2.2 WIRING AND TERMINATIONS

A. Recommended external cable shall be rated 90 °C for all designs. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.

2.3 ENCLOSURE

A. The enclosure shall be made of heavy-gauge steel. All transformer shall be equipped with wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 °C. The core of the transformer shall be grounded to the enclosure.

B. The enclosure construction shall be ventilated, NEMA rated indoor or outdoor type, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt. On outdoor units provide suitable weather shields over ventilation openings.

C. Enclosures shall be finished with ANSI 61 color weather-resistant enamel.

2.4 ACCEPTABLE MANUFACTURERS:
A. Transformers shall be as manufactured by:
   1. Square D
   2. Eaton Cutler-Hammer
   3. General Electric
   4. Or approved equal.

2.5 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 ANSI and NEMA standards.
   1. Ratio tests at the rated voltage connection and at all tap connections.
   2. Polarity and phase relation tests on the rated voltage connection.
   3. Applied potential tests.
   4. Induced potential test.
   5. No-load and excitation current at rated voltage on the rated voltage connection.

PART 3 – INSTALLATION

A. Install equipment as shown on the drawings and according to manufacturer’s recommendations.

B. All wall mounted units shall be mounted as high possible, except larger units shall be floor mounted. Where a conflict occurs with other trades, apply to the Project Manager for a resolution of the conflict. Where relocation of transformer(s) and/or panel(s) is required, make all changes at no cost to the Airport.

C. Anchor transformer securely according to manufacturer and seismic recommendations. Strength of bolts used to secure transformer shall be sufficient to resist shear and uplift provided by force equal to one half of the equipment mass applied horizontally at center of gravity.

END OF SECTION 26 12 16
SECTION 26 13 13 – MEDIUM-VOLTAGE SWITCHGEAR

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes medium-voltage (15KV) freestanding or close-coupled metal-clad switchgear and vacuum circuit breakers.

B. The Contractor shall furnish and install the equipment as specified herein and as shown on the contract drawings.

1.2 RELATED SECTIONS

A. Metal-Enclosed Bus – Medium Voltage

B. Power System Study

1.3 REFERENCE STANDARDS

A. American National Standards Institute:
   1. ANSI C12.1 - Code for Electricity Metering.
   3. ANSI/IEEE C37.04 and .06 - Standard ratings and preferred ratings for Indoor AC Medium-Voltage Circuit Breakers used in Metal-Clad Switchgear.
   4. ANSI/IEEE C37.11 - Requirements for electrical control for AC High-Voltage Circuit Breakers rated on a symmetrical current basis or a total current basis.
   8. IEEE 48 - Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV.
   10. IEEE C37.20.2 - Standard for Metal-Clad and Station-Type Cubicle Switchgear.
   11. IEEE 1115-200 - Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications
   13. NEMA SG4 - Alternating Current High Voltage Circuit Breakers.
   14. NEMA SG5 - Power Switchgear Assemblies.
   15. National Electric Code, latest version
   16. National Fire Protection Association 70E, latest version
   17. California Fire Code, latest version
18. California Building Code, latest version

1.4 SUBMITTALS FOR REVIEW AND APPROVAL

A. Shop Drawings: Indicate electrical characteristics and connection requirements, outline dimensions, connection and support points, weight, specified ratings and materials.

B. Product Data: Submit electrical characteristics and connection requirements, standard model design tests, and options.

C. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.

D. Manufacturer’s Field Reports: Indicate activities on site, final adjustments and overcurrent protective device coordination curves, adverse findings, and recommendations.

E. Where applicable the following additional information shall be submitted to the Project Manager/Engineer:

1. Single line diagram.

2. Schematic diagram and wiring diagrams for the substation showing detail wiring for power, signal and control systems, relay systems and differentiate between manufacturer-installed and field-installed wiring.

3. Nameplate schedule.

4. Component list.

5. Conduit entry/exit locations.

6. Assembly ratings including:
   a. Short circuit rating.
   b. Voltage.
   c. Continuous current.
   d. Basic Impulse level for equipment over 600 volts.

7. Major component ratings including:
   a. Voltage.
   b. Continuous current.
   c. Interrupting ratings.

8. Cable terminal sizes.


10. Connection details between close-coupled assemblies.

11. Composite floor plan of close-coupled assemblies.

12. Switchgear, battery charger and battery rack outline, circuit breaker test cabinet, and switchgear elevation.
13. Key interlock scheme drawing and sequence of operations.

14. Instruction manuals, including time current curves, for all protective relays.

15. Bus configuration with size and number of conductors in each bus run, including phase, and ground conductors of main and branch buses.

16. Battery and charger configuration, capacity, wiring including circuit protection and operation and manufacturer’s information.

F. Submit one (1) hard copy and one (1) digital copy of the above information to Engineer/Project Manager for review and approval immediately after the contract award.

1.5 CLOSEOUT SUBMITTALS

A. The following information shall be submitted for record purposes prior to final payment:

1. Project Record Documents: Include copy of manufacturer’s certified drawings and final as-built drawings.

2. Operation and Maintenance Data: Submit operating instructions for manually and electrically opening and closing circuit breakers, and include maintenance instructions for circuit breaker removal, replacement, testing and adjustment, and lubrication.

3. Include circuit breaker recommended spare parts list.

4. Certified production or factory test reports.

5. Installation information including equipment anchorage provisions.


1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience. The manufacturer of the switchgear must be the same as the manufacturer of the circuit breaker. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Testing Agency: Company member of International Electrical Testing Association and specializing in testing products specified in this section with minimum five years documented experience.

C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for Zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g’s (3.2-11 Hz), and a ZPA of 0.86g’s applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards:

1. The Contractor shall coordinate the equipment mounting provision, prepared and stamped by
a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.7 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. Lift only with lugs provided. Handle carefully to avoid damage to internal components, enclosure, and finish.

C. Switchgear being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition. Protect products from weather and moisture by covering with heavy plastic or canvas and by maintaining heating within enclosure.

D. Contractor shall accept equipment on site and inspect for shipping damage.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Conform to specified service conditions during and after installation of switchgear.

1.9 FIELD MEASUREMENTS

A. Where applicable, verify field measurements prior to fabrication.

B. If necessary, the manufacturer shall coordinate first with the building contractor as to the exact conduit stub-up locations and other field conditions.

1.10 SEQUENCING

A. Sequence work to avoid interferences with building finishes and installation of other products.

1.11 MAINTENANCE MATERIALS

A. Include circuit breaker recommended spare parts list.

1.12 EXTRA MATERIALS/ACCESSORIES

A. Submit one (1) racking handle(s) with equipment. Charging handle to be furnished on each breaker mechanism.

B. Provide one set of spare control fuses for each set installed.
C. For all switchgear with circuit breakers in upper compartments, provide one circuit breaker lifting device - portable, floor-supported with a roller base.

D. Provide one test cabinet.

E. Provide one test jumper cable.

F. Provide Space Heaters: For 120-volt external source, sized by switchgear manufacturer.

G. Provide one motorized remote control racking accessory.

H. Provide levering crank for moving the breaker between test and connected positions.

PART 2 – PRODUCTS

2.1 MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR

A. Manufacturer for the vacuum circuit breakers (VCBs) and vertical stationary structure assembly shall be the same. It shall be as manufactured by:

1. Square D.
2. Or approved equal

B. Product Description: IEEE 37.20.2, metal clad switchgear assembly shall consist of indoor enclosure containing circuit breakers and the necessary accessory components all factory assembled (except for necessary shipping splits) and operationally checked. The assembly shall be a self-supporting and floor mounted on a level concrete pad. The integrated switchgear assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.

C. Nominal Voltage: 12,470V, three-phase ungrounded, 60 Hz, 750 MVA class or higher.

D. Maximum Voltage: 15 KV

E. Impulse Withstand (BIL): 95KV

F. Power Frequency Withstand: 18 KV, 1 minute test.

G. Voltage and Insulation Levels: Conform to IEEE C37.20.2.

H. Main Bus Ampacity: 2000 amperes, continuous or higher.

I. Momentary Current Rating: Equal to the circuit breaker close and latch rating.

2.2 CIRCUIT BREAKERS

A. Product Description: IEEE C37.04, vacuum interrupter circuit breaker.

B. Circuit Breaker Operator: Spring-charged stored energy with electric operator to IEEE C37.11.

C. Rated Permissible Tripping Delay: 2 seconds.

D. Short-Circuit Rating: 18 kA rms, at rated maximum voltage.
E. Operation Endurance Capability: ANSI C37.06.

F. Rated Tripping Voltage: 125 Volt, DC from battery power supply in switchgear; furnish terminals.

G. Rated Control Voltage, Closing: 125 Volt, DC.

H. Furnish circuit breakers with one vacuum interrupter per phase. Breakers of same type and rating shall be completely interchangeable. The circuit breaker shall be operated by means of a stored energy mechanism which is normally charged by a universal motor but can also be charged by the manual handle supplied on each breaker for manual emergency closing or testing. The closing speed of the moving contacts is to be independent of both the control voltage and the operator. Provide a full front shield on the breaker. Secondary control circuits shall be connected automatically with a self-aligning, self-engaging plug and receptacle arrangement when the circuit breaker is racked into the connected position. Provision shall be made for secondary control plug to be manually connected in test position.

A minimum of 4 auxiliary contacts (2a 2b), shall be provided for external use. Provisions shall be made for 6 additional cell-mounted auxiliary contacts both MOC and TOC type for external use. The racking mechanism to move the breaker between positions shall be operable with the front door closed and position indication shall be visible with door closed.

I. An interlocking system shall be provided to prevent racking a closed circuit breaker to or from any position. An additional interlock shall automatically discharge the stored-energy operating mechanism springs upon removal of the breaker out of the compartment.

2.3 DC POWER SOURCE

A. Provide a battery charger, storage batteries, and required charger control devices:

1. Battery: Nickel Cadmium designed specifically for 5-hour minimum stand-by service for switchgear operation. Battery shall provide adequate power for operating all circuit breaker mechanisms at least twice successively and to provide power for relays and breaker indicating lights.

2. Battery shall be sized per IEEE 1115-200 Standard and it shall be of low maintenance type.

3. Battery rating shall be 125VDC nominal, with design margin of 0.85 and aging factor of 0.8. It shall have a minimum of 55 cells per bank and be able to support switchbox functions for 5 hours minimum at 77 ºF room temperature. Capacity shall be adequate to support future feeder units.

4. Batteries shall be housed on a battery rack. Battery rack shall be equipped with battery restraints to prevent displacement due to seismic motion. Rack shall have the proper coating to resist battery chemicals and chemical absorbing pads. The battery systems shall be seismically braced in accordance with the California Building Code.

5. The battery system shall include an approved method and materials for the control and neutralization of a spill of free-flowing electrolyte.

6. Battery charger shall be designed for charging nickel cadmium battery. It shall be an automatic solid-state controlled device which alters its change from “float” rate to “charge” rate automatically by sensing the condition of the battery. It shall also have the capability to automatically turn itself off when the batteries are fully charged. Charge rate shall be enough to recharge the battery from depleted to fully charged condition in 8 hours. Charger shall have output voltage and current readout meters, low dc voltage, loss of ac supply and ground fault relays for alarms.
7. Switchgear manufacturer shall verify capacity of batteries and shall ensure that battery size is adequate to support all new and future circuit breakers and relays for the switchgear installed.

2.4 COMPONENTS

A. Stationary Structure

1. The switchgear shall consist of sections including breaker compartments and auxiliary compartments assembled to form a rigid self-supporting completely enclosed structure providing steel barriers between sections.

2. The sections are divided by metal barriers into the following separate compartments:
   a. Circuit breaker, instrument, main bus, auxiliary device and cable. Each feeder section may have up to two circuit breaker compartments.

B. Circuit Breaker Compartment

1. Each circuit breaker compartment shall be designed to house a horizontal drawout metal-clad vacuum circuit breaker. The stationary primary disconnecting contacts are to be silver-plated copper and mounted within glass polyester support bushings. The movable contacts and springs shall be mounted on the circuit breaker element for ease of inspection/maintenance.

2. Entrance to the stationary primary disconnecting contacts shall be automatically covered by metal shutters when the circuit breaker is withdrawn from the connected position to the test or disconnected position or removed from the circuit breaker compartment. Extend a ground bus into the circuit breaker compartment to automatically ground the breaker frame with high-current spring type grounding contacts located on the breaker chassis when in the test and connected positions. Guide rails for positioning the circuit breaker and all other necessary hardware are to be an integral part of the circuit breaker compartment. Blocking devices shall interlock breaker frame sizes to prevent installation of a lower ampere rating or interrupting capacity element into a compartment designed for one of a higher rating. It shall be possible with indoor switchgear to install a circuit breaker into a bottom compartment without use of a transport truck or lift device.

C. Cable Compartment/Ground Bus

1. Compression type cable lugs shall be furnished as shown on plans. The ground bus shall extend through this compartment for the full length of the switchgear. Auxiliary bus, if needed, and load bus support NEMA Class A-20 standoff insulators shall be porcelain.

D. Main Bus Compartment

1. The main bus is to be rated 2000 amps and be fully insulated for its entire length with an epoxy coating by the fluidized bed process. The conductors are to be silver-plated copper and be of a bolted not welded design. Access to this compartment is gained from the front or rear of the structure by removing a steel barrier. Provide standard provisions for future extension.

E. Bus Duct

1. If applicable, the bus is to be rated 2000 amps and be fully insulated for its entire length with an epoxy coating by the fluidized bed process. The conductors are to be silver-plated copper and be of a bolted not welded design. Bus duct shall be seismically braced and enter the top of the switchgear compartment as shown on the plans.
F. Doors and Panels
   1. Meters, control switches, etc., shall be mounted on a formed front-hinged panel for each circuit breaker compartment.

G. Instrument Transformers
   1. Current transformers: Each breaker compartment shall have provision for front-accessible mounting of up to four current transformers per phase (ANSI standard relay accuracy. For high accuracy and/or ratios below 150:5, two per phase), two on bus side and two on cable side of circuit breaker. The current transformer assembly shall be insulated for the full voltage rating of the switchgear. The current transformers wiring shall be Type SIS #12 AWG. Relaying and metering accuracy shall conform to ANSI Standards.
   2. Voltage transformers are drawout mounted with primary current-limiting fuses and shall have ratio as indicated. Primary fuse holders shall be an integral part of the assembly. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers and shall have metering accuracy per ANSI Standards.

H. Control Wiring
   1. The switchgear shall be wired with type SIS #14 AWG, except for current transformer where SIS #12 size wire is specified. The switchgear shall be provided with terminal blocks for outgoing control connections. Wire markers shall be provided for each end of all control wires.
   2. Crimp type secondary terminals insulated ring shall be furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs, or terminal blocks which have two or more wire connectors. Secondary control wire shall be enclosed in grounded metal troughs where they pass through primary compartments. Current transformer leads shall be brought out to accessible shorting block terminals.

I. Protective Relays: Provide relays as indicated on drawings for each circuit breaker.
   1. Relays shall be semi-flush, drawout, back-connected, switchgear type conforming to ANSI C37.90. Relays shall be of the solid-state type. They shall have rectangular cases, finished to resist rust and corrosion. Relays shall have built-in test facilities. Auxiliary relays shall be provided as required for proper operation of the switchgear.
   2. Relays shall be manufactured by Basler or approved equal.

J. Indicating Lights: Indicating lights shall be rated 24 volts and shall be telephone switchboard type, Type T2, or an equivalent LED type.

K. Terminal Blocks: Terminal blocks shall be rated 600 volts, 25 amperes minimum. Blocks shall have washer, head screws, barriers between terminals and for outgoing circuits, white marking strips.
   1. Short circuiting type terminal blocks shall be provided for each current transformer, including any external current transformer circuits that enter the switchgear.

L. Control Switch: Control switches shall be switchboard type with contacts rated 10 amperes, 600 volts.

M. Test Switches: Provide test for each current and voltage circuit. Switches shall be flush or semiflush mounted, back connected and with cover. Barriers shall be provided around switches. Current switch
shall be of the short circuiting type with test jack.

N. Wire and Cable Terminations: All control wiring shall be neatly arranged and securely fastened to the switchgear frame structure. All wires shall be labeled with permanent sleeve type wire markers. The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations and provide minimum of ten% spare terminal connections.

O. Power Meter: Power Logic Type CM4000T; For selected circuit breakers, install monitor with digital display and with waveform capture wired for communications to SCADA, multi-function microprocessor-based metering/data acquisition device. Meter shall be drawout, flush-mounted switchboard type. Protocol for remote transmission shall be open architecture type and will be determined prior to approving the submittals. Up to 6 power meters may be provided by the Airport and it shall be installed by the switchgear manufacturer at their factory. Switchgear manufacturer to furnish and install metering CTs.

P. Communications

1. The equipment shall be able to communicate with existing SMS Powerlogic Monitoring System. Equipment shall be Transparent Ready web-enabled equipment, featuring an (Ethernet interface and integral web server, and have the following communications.
   a. Transparent Ready TRE-2 plus SMS (custom engineered for Airport) Option Ethernet Server, with Enhanced Monitoring: In addition to the 5 summary web pages, a “home” page shall be provided for each individual communicating device, to display detailed, real-time information, as appropriate for the device type. Also, historical energy data shall be logged automatically for each device, if appropriate for the device type. Web pages shall be provided for displaying the historical data logged from each device in graphical Time Trend plots, preprogrammed and tested. A front-accessible Ethernet port (RJ-45 connector) shall be provided for temporary local access via Notebook PC, etc., suitable for use during commissioning and normal operations.

2. A multi-point, RS485 Modbus® serial communications network shall be provided within the equipment to interconnect all breaker trip units and metering devices equipped with communications. (Note: for full functionality, these devices should be specified with power metering, when available.)

3. The serial communications network shall be wired to a PowerLogic® Ethernet Gateway/Web Server (“Ethernet Server”) in the incoming section of the equipment for remote data access via customer’s Local Area Network (LAN) or intranet.

Q. Contractor shall supply switchgear with two control power transformers with 30 KVA, 208/120, 3 phase minimum ratings and panelboards as shown on the drawings. Panelboards shall have main circuit breaker. Panelboards shall be supplied with circuit breakers as necessary to provide power for control of circuit breakers, cubicle heaters, lighting and convenience receptacles. Control power transformers shall be wired to provide an automatic transfer of control power if one of the incoming breakers is opened.

R. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

2.5 FABRICATION

A. Construction: Each equipment bay shall be a separately constructed cubicle assembled to form a rigid
free standing unit. Minimum sheet metal thickness shall be 11-gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure. The rear covers shall be removable to assist installation and maintenance of bus and cables. Each individual unit shall be braced to prevent distortion.

B. Dimensions: Standard dimensions per indoor section are: 36 in W x 95 in H x 92 in D

C. The metal-clad switchgear shall be fully assembled, inspected and tested at the factory prior to shipment. Large line-ups shall be split to permit normal shipping and handling as well as for ease of rejoining at the job site.

D. Conform to requirements of IEEE C37.20.2.

E. Include continuous ground bus through switchgear assembly, securely connected to frame of each cubicle.

2.6 METERING TRANSFORMERS

A. Current Transformers: IEEE C57.13; 5 ampere secondary, secondary winding and secondary shorting device, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: IEEE C57.13; 120 volts secondary, disconnecting type with integral fuse mountings, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

2.7 FACTORY FINISHES

A. Clean surfaces before applying paint. All steel parts, except galvanized (if used), shall be cleaned and iron phosphate pre-treatment applied prior to paint application.

B. The finish shall consist of a coat of gray (ANSI-61), thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray.

C. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.

2.8 SOURCE QUALITY CONTROL

A. Test in accordance with IEEE C37.20.2.

B. Make completed switchgear available for inspection at manufacturer’s factory prior to packaging for shipment.

C. Allow witnessing of factory inspections and tests at manufacturer’s test facility. Notify Project Manager 3 weeks before inspections and tests are scheduled. See related requirements on Part 3.5 of this section.

PART 3 – EXECUTION

3.1 EXISTING WORK
A. Perform the following where applicable:
   1. Disconnect and remove abandoned switchgear.
   2. Clean and repair existing switchgear space to install new equipment.

3.2 EXAMINATION

A. Visually inspect switchgear for evidence of damage and verify that surfaces are ready to receive work.
B. Visually inspect to confirm that all items and accessories are in accordance with specifications and drawings.
C. Verify field measurements are as shown on drawings or per manufacturer specifications.
D. Verify that required utilities (e.g., control voltage for heater circuits on outdoor switchgear) are available, in proper location, and ready for use.
E. Beginning of installation means installer accepts existing surface conditions.

3.3 INSTALLATION

A. Install in accordance with applicable requirements of the NEC, IEEE C37.20.2, manufacturer’s instructions, and in accordance with recognized industry practices.
B. Install switchgear plumb and level and with each section aligned properly.
C. Make electrical connections between equipment sections using connectors furnished by manufacturer.
D. Ground and bond switchgear in accordance with the specification section entitled, “Grounding and Bonding.”
E. Bending of high-voltage cables should be avoided or minimized. All necessary bends should meet at least the minimum radii specified by the cable manufacturer.

3.4 NAMEPLATES

A. Install engraved plastic nameplates in accordance with the specification section entitled “Electrical Identification.”
B. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum. Furnish master nameplate for each switchgear lineup giving information in accordance with IEEE Std C37.20.2-1999, section 7.4.1. Circuit nameplates shall be provided with circuit designations as shown on single-line diagrams.
C. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s wiring diagrams.
3.5 FACTORY TESTING

A. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI standards.
   1. Alignment test with master cell to verify all interfaces and interchangeability.
   2. Circuit breakers operated over the range of minimum to maximum control voltage.
   3. Factory setting of contact gap.
   4. One-minute dielectric test per ANSI standards.
   5. Final inspections and quality checks.

B. The following production test shall be performed on each breaker housing:
   1. Alignment test with master breaker to verify interfaces.
   2. One-minute dielectric test per ANSI standards on primary and secondary circuits.
   3. Operation of wiring, relays and other devices verified by an operational sequence test.
   4. Final inspection and quality check.
   5. The manufacturer shall provide certified copies of factory test reports.
   6. Factory tests as outlined above shall be witnessed by the owner’s representative. The manufacturer shall notify the owner at least 3 weeks prior to the date the tests are to be performed. The manufacturer shall include all cost of transportation, lodging, daily meals and incidental expenses for up to 5 owner’s representatives assigned by the Project Manager.

3.6 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 10 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.
   2. Visually inspect for physical damage.
   3. Verify key interlock operation where applicable.
   4. Perform low frequency withstand (Hi-Pot) tests according to ANSI/IEEE C37.20.2, paragraph 5.5.
   5. Inspect and test in accordance with NETA ATS, except Section 4.
   6. Perform inspections and tests listed in NETA ATS, Section 7.6.2.
   7. Perform start-up tests in accordance with manufacturer’s instruction manual.
   8. Adjust protective relays in accordance with coordination study.
   9. A manufacturer representative shall perform field inspection and testing.
10. Touch-up paint all chips and scratches with manufacturer-supplied paint and leave remaining paint with owner.

11. Written report showing the inspection and test results as required above.

3.7 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.

3.8 FIELD ADJUSTMENTS

A. The relays shall be set in the field by a qualified representative of the manufacturer, retained by the Contractor, in accordance with settings designated in a coordinated study of the system as required elsewhere in the contract documents.

3.9 TRAINING

A. The Contractor shall provide a training session for up to 5 owner’s representatives for minimum of 3 normal workdays at the jobsite location determined by the Owner.

B. The training program shall be determined by the Airport Project Manager and can include medium voltage substation design, protective device coordination and other major electrical components.

END OF SECTION 26 13 13
SECTION 26 18 29 – MEDIUM-VOLTAGE ENCLOSED BUS

PART 1 – GENERAL

1.1 SCOPE

A. The Contractor shall furnish and install the equipment as specified herein and as shown on the contract drawings.

B. The medium voltage bus distribution system and associated equipment shall have the electrical characteristics and arrangements as shown on the drawings.

1.2 RELATED SECTIONS

A. Section 26 13 13 – Medium-Voltage Switchgear

1.3 REFERENCES

A. The bus and components shall be built in accordance with the latest ANSI (C37.23) and other applicable standards.

1.4 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:
   1. Master drawing index
   2. Riser or isometric drawing
   3. Floor plan
   4. Component list
   5. Conduit entry/exit locations
   6. Assembly ratings including:
      7. Short-circuit rating
      8. Voltage
      9. Continuous current
     10. Basic impulse level
     11. Cable terminal sizes
     12. Busway connection to other equipment
     13. Space heater circuit wiring diagram where applicable
     14. Descriptive bulletins
     15. Product data sheets.

1.5 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:
   1. Final as-built drawings and information for items listed in paragraph PERTAINING TO Review/Approval submittals.
2. Certified production test reports
3. Installation information
4. Seismic certification and equipment anchorage details.

B. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

1.6 QUALIFICATIONS

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

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

C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g’s (3.2-11 Hz), and a ZPA of 0.86g’s applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.7 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.

1.8 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.

1.9 FIELD MEASUREMENTS
A. The Contractor shall be responsible for making all field measurements necessary to fabricate, install and connect the bus system.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Cutler-Hammer
B. Square D
C. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 RATINGS

A. Voltage: 12.47 kV, 3 phase, 3-wire, with ground bus.
B. Current rating: as shown on drawings.
C. Short-circuit rating: 100 kA RMS symmetrical.
D. Basic impulse level: 95 kV.

2.3 BUS

A. The conductors shall be 100% conductivity bar-type copper with silver-plated joints. These bars shall be mounted on supports of track-resistant, flame-retardant xenoy polymer, glass polyester, or epoxy, and shall be insulated their entire length by fluidized epoxy coating for 2400-volt service and above. Typical bus joints shall use double splice plates and be insulated with removable boots. For non-standard joints, heat shrink tubing or tape may be used to insulate the joint. The conductors shall be capable of carrying its rated current continuously without exceeding a temperature rise of 65 ºC based on a 40 ºC ambient. Conductors shall be braced to withstand the available fault currents as indicated on the contract drawings.

B. A 0.25 x 2.0-inch bare copper ground bus shall be supplied and bolted to each enclosure to provide continuous electrical ground when adjacent enclosures are connected together, to minimize the possibility of circulating currents.

2.4 WIRING/TERMINATIONS

A. Provide an external 2-hole ground pad at each end for ground connections or connect the ground bus in the enclosure to the ground bus in the terminal equipment as applicable.

2.5 MISCELLANEOUS DEVICES

A. Provide wall flanges, vapor barriers, expansion joints, and equipment terminations where indicated on drawings.

2.6 ENClosures

A. The enclosures shall be #11-gauge steel or equivalent aluminum, as applicable. Enclosures shall be
dustproof with bolted removable covers.

2.7 FINISH

A. The finish shall consist of one (1) coat of gray (ANSI 61) thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel. The coating shall have corrosion resistance of 600 hours to 5% salt spray. Prior to shipment, the complete assemblies, indoor as well as outdoor, shall be given 1.5 to 2.0 mil thick exterior finish spray coat of air drying high-gloss gray enamel.

2.8 ACCESSORIES

A. The indoor enclosures shall be designed to be hung from overhead by hangers. The hanger rods and steel supports shall be supplied and installed by the Contractor. The manufacturer shall provide mounting provisions and supply all necessary information to the Contractor for the design of these supporting devices.

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 ANSI and NEMA standards.

1. Normal frequency dielectric
2. Space heater electrical operation and control wiring check

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

3.2 FIELD QUALITY CONTROL – NOT INCLUDED

3.3 MANUFACTURER’S CERTIFICATION – NOT INCLUDED

3.4 TRAINING

A. The Contractor shall provide a training session for up to 5 owner’s representatives for minimum of one (1) normal workday at a jobsite location determined by the owner.

B. The training session shall be conducted by a manufacturer’s qualified representative.

3.5 INSTALLATION

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

3.6 FIELD ADJUSTMENTS – NOT INCLUDED

END OF SECTION 26 18 29
SECTION 26 20 00 – DISTRIBUTION EQUIPMENT

PART 1 – GENERAL

1.1 PROVIDE, FURNISH AND INSTALL

A. Distribution switchboards.
B. Metering Cabinets.
C. Distribution Panels.
D. Panelboards.
E. Dry-type transformers.
F. Mobile Generator Connection Enclosures.
G. All necessary and required accessories and devices.

1.2 RELATED SECTIONS

A. Cast-in-Concrete: Concrete pad
B. Short Circuit/Coordination Study

1.3 STANDARDS

D. ANSI C37 Series.
E. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
F. NEMA KS 1 - Enclosed Switches.
G. NEMA PB-2
H. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
I. UL 891, UL 67, UL 50, UL 489, UL 414

1.4 SUBMITTALS
A. Shop Drawings: Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral, and ground; and switchboard instrument details, and all other details required for each product in paragraph 1.1.

B. Product Data: Provide electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all circuit breakers and other equipment.

C. Test Reports: Indicate results of factory production tests.

D. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 OPERATION AND MAINTENANCE DATA

A. Maintenance Data: Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum ten years documented experience.

B. Major components, such as circuit breakers, etc., shall be manufactured by the same manufacturer.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.8 PRE-INSTALLATION CONFERENCE

A. Convene one week prior to commencing work of this Section.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to site under provisions of Division 1 sections provisions.

B. Deliver in manufacturer’s standard maximum width shipping splits, individually wrapped for protection and mounted on shipping skids.

C. Accept switchboards and other equipment on site. Inspect for damage.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with NEMA PB 2.1 and manufacturer’s written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard/other equipment internal
components, enclosure, and finish.

1.10 ENVIRONMENTAL REQUIREMENTS
   A. Conform to NEMA PB 2 service conditions during and after installation of switchboards.

1.11 FIELD MEASUREMENTS
   A. Verify that field measurements are as indicated instructed by manufacturer.

1.12 MAINTENANCE MATERIALS
   A. Provide maintenance materials under provisions of Division 1 Specifications.
   B. Provide two of each key.

1.13 EXTRA MATERIALS
   A. Furnish under provisions of Division 1 Specifications.

1.14 PERFORMANCE REQUIREMENTS:
   A. Wind Loads – Structural Design Basis:
      1. Importance Factor – See Structural Design Basis on the structural drawings.
   B. Seismic Design – Structural Design Basis
      1. Importance Factor – See Structural Design Basis on the structural drawings.
   C. Live Loads – Structural Design Basis
      1. Importance Factor – See Structural Design Basis on the structural drawings.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
   A. Square D or approved equal.

2.2 DISTRIBUTION SWITCHBOARD
   A. Description: Designed for a selective system for indoor use, of code gauge steel, with electrical ratings
      and configurations as indicated on drawings, all enclosed with front, rear and side covers, UL listed.
   B. Bus Material: Copper
   C. Ground Bus: Copper, extend length of switchboard.
   D. Include all devices and accessories, including molded case circuit breakers, as for a typical installation
      and as shown on drawings. Short circuit ratings as per specification section entitled “Power Systems
      Study”.
   E. Main devices shall be individually mounted; and branch devices group mounted.
F. All overcurrent devices shall be 100% rated as per UL/NEC.

G. Circuit breakers rated 800 Amp and higher shall be provided with ground fault interrupter, except those used as mains.

H. Circuit breakers rated 800 Amp and higher shall have electronic trip units with interchangeable trip plugs, true RMS sensing and the following adjustments and features:
   1. Adjustable short time with I2T and delay bands.
   2. Adjustable instantaneous.
   3. Adjustable ground fault with I2T and delay bands. Provide on 480/277V only.
   4. Ammeter, 3 phase.

2.3 METERING CABINETS

A. The metering cabinet shall be a minimum UL type 1 listed steel enclosure with factory supplied knock-outs.

B. The cabinet shall be lockable and provide for the application of a security seal.

C. The cabinet shall include built in circuit protection and disconnect switch for the metering equipment.

D. The enclosure shall have one set of incoming terminals for connecting the voltage metering leads.

E. Control power and voltage sensing power shall be separated for distribution to each meter from this main set of incoming terminals.

F. Control power transformers shall not be needed for any power systems up to and including 480 volts.

G. Standard wiring harnesses for control power and voltage sensing shall be used to internally connect each row of meters. The harness may daisy-chain the voltage connections from meter to meter on each row of meters. Finger safe terminals are to be used to terminate the meter end of the wiring harness.

H. The meters shall be connected with common daisy chain wiring for the communications leads. The communication wiring should be a single loop with all meters connected to the circuit and each end terminated in a common location. Communication wiring shall be arranged in such a manner as to minimize interference from the power wiring.

I. The enclosure shall have shorting terminal blocks for connecting the current transformer leads from the field to the meters. Shorting terminal blocks will only be provided for a number of meters ordered with each enclosure. The locations for shorting terminal blocks shall be pre-drilled and labeled for ease of installation should meters be added to the enclosure after installation at the customer site. A factory installed wiring harness shall be provided to connect the CT circuit from the shorting block to the meter.

J. The metering cabinet shall make provisions for adding meters in the field without cutting or splicing the voltage or communication wiring harnesses.
K. The metering cabinet shall have separate terminal blocks for incoming and outgoing communications circuit connections.

L. The metering cabinet shall have space sufficient for the addition of an Ethernet Gateway, wireless communications and power supply as required.

M. Metering cabinet shall be Square D power logic or equal.

2.4 DISTRIBUTION PANELBOARD

A. Description: Power distribution panelboard, fully complying with the Standards and NEC, configured as per drawings, with copper main, neutral and ground bus and interconnections with all devices and accessories for a typical installation. This equipment shall be similar in construction and all other details to the panelboard specified below. The size of neutral bus shall not be less than that of phase bus bars. Circuit breakers shall be bolt-on. Plug-on breakers not acceptable.

2.5 PANELBOARD

A. Panelboards shall be Square D or equal, rated for the intended voltage.

B. Gutters shall be not less than four inches wide on all sides.

C. Provide galvanized steel boxes and sheet steel fronts with door and combination lock and catch, and two keys. Key all locks alike.

D. Provide vault type handles and three point catches for doors over 36 inches in height.

E. Provide reinforced galvanized sheet steel frame with bus bars and circuit breakers properly supported to prevent vibration and to withstand effect of the indicated short circuit current. Provide solderless type bus terminals suitable for copper cable. Bus bars shall be sequence phased and shall run full height of the panelboard. The size of neutral bus shall not be less than that of phase bus bars.

F. Provide “spaces” indicated on drawings with all necessary mounting hardware permitting easy future installation of breakers in the field.

G. Provide bolted, molded case circuit breakers as scheduled on drawings.

H. Provide handle ties in each panelboard for all multi-wire branch circuits installed with a common neutral conductor.

I. Provide handle “lock-on” devices for all circuit breakers supplying current to time switches, clocks and clock controls, refrigeration equipment, heating controls, emergency system sensing relays, locally switched circuits, night lighting circuits and other devices which should not be turned off.

J. Provide ground bus for equipment grounding conductor in all panels connecting to feeders and branch circuits having equipment grounding conductors.

K. Provide isolated ground bus where indicated on Panel Schedules.

L. For SSR rooms provide electronic grade panelboard with 3 phase surge suppressor, Current TECHNOLOGY Model EGP or equal where shown on panelboard schedules.
M. All bussing and interconnections shall be of copper.

N. Front cover shall be door-in-door construction.

O. Provide permanent circuit numbers. Stuck on numbers are not acceptable.

2.6 DRY-TYPE TRANSFORMER

A. Description: Ventilated dry-type two winding transformer with 2200C class insulation, 1150C winding temperature rise over 400C ambient, fully complying with ANSI C57 series Standards, 200% nameplate load for one-half hour, with primary taps, sound levels below NEMA ST-20 maximum levels, manufacture by Square D or approved equal. Transformer windings shall be of copper.

2.7 MOBILE GENERATOR CONNECTION ENCLOSURE

A. Description: The mobile generator connection enclosure shall be furnished as per drawings. All current carrying components, including the bus and the contacts, shall be of copper. The enclosure shall be NEMA 4X design. The whole equipment shall comply with Standards and UL listed. The interlocking arrangement for the circuit breakers shown on the drawings shall be noted in the design of this equipment.

B. Enclosure shall include a red Mushroom head emergency trip push-button. Button shall have 4 sets of normally open contacts. Contacts shall be wired to a fixed terminal board in the enclosure for wiring to shunt trips in breakers by the contractor. The button shall be guarded in a top hinged, clear see through case so that it cannot be accidentally depressed but can be easily reached when needed.

2.8 GENERAL

A. All equipment shall have adequate short circuit current ratings as per the specification section entitled “Power Systems Study”.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify conditions under provisions of Division 1 Specifications.

B. Verify that surface is suitable for all equipment installation.

3.2 PREPARATION

A. Provide concrete housekeeping pad where necessary.

3.3 INSTALLATION

A. Install equipment in locations shown on Drawings, in accordance with manufacturer’s written instructions and Standards.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard and other equipment specified herein.

3.4 FIELD QUALITY CONTROL
A. Field inspection and testing will be performed under provisions of Division 1 provisions and as per NETA, ATS as applicable.

B. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

C. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each, at test voltage of 1000 volts; minimum acceptable value for insulation resistance is 2 megohms.

D. Check tightness of accessible bolted bus joints using calibrated torque wrench.

E. Physically test key interlock systems to insure proper function.

3.5 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections in accordance with manufacturer's instructions.

C. Adjust circuit breaker trip and time delay settings to values indicated or as instructed by the Engineer.

3.6 CLEANING

A. Touch up scratched or marred surfaces to match original finish.

B. Clean and vacuum equipment interior prior to energizing equipment.

3.7 INSTALLATION OF DRY TYPE TRANSFORMERS

A. Mount floor mounted transformers on neoprene isolators and securely bolt to floor. Provide minimum of six inches of separation from side and back walls. Where these walls are constructed of combustible material, increase this distance to twelve inches.

B. Provide flexible conduit connections.

END OF SECTION 26 20 00
SECTION 26 22 00 – LOW-VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, single-phase or 3-phase, with capacities up to 225 kVA:

1. Distribution transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.


C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.” Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. 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.”

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.

D. Qualification Data: For testing agency.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency’s Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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

E. Comply with IEEE C57.12.91, “Test Code for Dry-Type Distribution and Power Transformers.”


1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, handle and store to manufacturer’s written instructions throughout periods during which equipment is not energized.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers:

1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Controlled Power Company.
5. General Electric Company.
8. Micron Industries Corp.
2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Copper.

2.3 LOW-VOLTAGE TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: Gray.

F. Taps for Transformers Smaller than 3 kVA: One 5% tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: One 5% tap above and one 5% tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5% taps above and four 2.5% taps below normal full capacity.

I. Insulation Class: 220 °C, UL-component-recognized insulation system with a maximum of 115 °C rise above 40 °C ambient temperature.

J. Energy Efficiency for all Transformers:

K. Windings: copper windings only.
   1. Transformers shall be low loss type with minimum efficiencies per 2016 US Department of
Energy when operated at 35% of full load capacity. Efficiency shall be tested in accord with NEMA TP2.

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</table>

L. Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section “Identification for Electrical Systems.”

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer’s written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section “Grounding and Bonding for Electrical Systems” have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION
   A. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”

3.3 CONNECTIONS
   A. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems.”
   B. Connect wiring according to Division 26 Section ”Low-Voltage Electrical Power Conductors and Cables.”

3.4 FIELD QUALITY CONTROL
   A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
   B. Perform tests and inspections and prepare test reports.
   C. Tests and Inspections:
      1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   D. Remove and replace units that do not pass tests or inspections and retest as specified above.
   E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
      1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
      2. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
   F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed “Satisfactory Test” label to tested component.

3.5 ADJUSTING
   A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions. Submit recording and tap settings as test results.
   B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING
   A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
SECTION 26 24 13 – SWITCHBOARDS

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes main and distribution switchboard(s) as herein specified and shown on the associated electrical drawings.

B. Related Sections:
   1. Division 26 - Grounding and Bonding for Electrical Systems.

1.2 REFERENCES

A. The switchboard(s) and overcurrent protection devices referenced herein are designed and manufactured according to the following appropriate specifications. American National Standards Institute:
   1. ANSI C12.1 - Code for Electricity Metering.

B. Institute of Electrical and Electronics Engineers:
   2. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

C. National Electrical Manufacturers Association:
   1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
   2. NEMA FU 1 - Low Voltage Cartridge Fuses.
   3. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
   4. NEMA PB 2 - Deadfront Distribution Switchboards.
   5. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.

D. Underwriter Laboratories Listing:
   1. UL 50 - Cabinets and Boxes.
   2. UL 98 - Enclosed and Dead Front Switches.
   3. UL 489 - Molded Case Circuit Breakers.
   4. UL 891 - Dead-Front Switchboards.
   5. UL 943 - Ground Fault Circuit Interrupters.
   6. UL 1053 - Ground-Fault Sensing and Relaying Equipment.
E. Federal Specification:

F. International Electrical Testing Association:

1.3 SUBMITTALS

   A. Division 1 General Requirements – Submittals: Submittal procedures.
   
   B. Shop Drawings: Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars for each phase, neutral, and ground; and switchboard instrument details.

   C. Product Data: Submit electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of equipment and components.

   D. Test Reports: Indicate results of factory production and field tests.

1.4 CLOSEOUT SUBMITTALS

   A. Division 1 General Requirements – Contract Closeout: Closeout procedures.

   B. Project Record Documents: Record actual locations, configurations, and ratings of switchboards and their components on single line diagrams and plan layouts.

   C. Operation and Maintenance Data: Submit spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.5 QUALIFICATIONS

   A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

   B. Furnish products listed by Underwriters Laboratories Incorporated and in accordance with standards listed in Article 1.03 - References.

   C. The manufacturing facility shall be registered by Underwriters Laboratories Inc. to the International Organization for Standardization ISO 9002 Series Standards for quality.

1.6 DELIVERY, STORAGE, AND HANDLING

   A. Division 1 General Requirements – Material and Equipment: Requirements for transporting, handling, storing, and protecting products.

   B. Deliver, store, protect, and handle products in conformance with manufacturer's recommended practices as outlined in applicable Installation and Maintenance Manuals.

   C. Each switchboard section shall be delivered in individual shipping splits for ease of handling. They
shall be individually wrapped for protection and mounted on shipping skids.

D. Inspect and report concealed damage to carrier within their required time period.

E. Store in a clean, dry space. Maintain factory protection and/or provide an additional heavy canvas or heavy plastic cover to protect structure from dirt, water, construction debris, and traffic. Where applicable, provide adequate heating within enclosures to prevent condensation.

F. Handle in accordance with NEMA PB 2.1 and manufacturer’s written instructions. Lift only by lifting means provided for this express purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Division 1 General Requirements – Material and Equipment

B. Conform to NEMA PB 2 service conditions during and after installation of switchboards.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 SEQUENCING

A. Division 1 General Requirements - Summary: Work sequence.

B. Sequence Work to avoid interferences with building finishes and installation of other products.

1.10 MAINTENANCE MATERIALS

A. Division 1 General Requirements – Contract Closeout: Spare parts and maintenance products.

B. Provide one (1) set of installation and maintenance instructions with each switchboard. Instructions are to be easily identified and affixed within the incoming or main section of the line-up.

1.11 WARRANTY

A. Division 1 General Requirements – Contract Closeout: Spare parts and maintenance products.

B. Manufacturer shall warrant equipment to be free from defects in materials and workmanship.

PART 2 – PRODUCTS

2.1 DISTRIBUTION SWITCHBOARDS

A. Manufacturers:

1. Square D Model.

2. Eaton/Cutler Hammer

3. Or approved equal
B. Substitutions must be submitted in writing 5 days prior to original bid date with supporting documentation demonstrating that the alternate manufacturer conforms to all aspects of the specifications herein.

C. The manufacturer of the switchboard shall be the same as the manufacturer of the circuit breakers or the switches mounted in the switchboard.

D. All new panel boards and switchboards on this project shall be by the same manufacture as the switchboard for the purposes of stocking common breaker types, series ratings, etc.

2.2 SWITCHBOARD – GENERAL

A. Product Description: NEMA PB 2, enclosed switchboard with electrical ratings and configurations as indicated on Drawings

B. Utility Metering Compartment: The utility current transformer compartment shall comply with the Airport specifications.

C. Distribution Panel board “XXXHDX” shall be Square D Type QED or approved equal, unless otherwise noted. Consult Drawings for the nameplate.

D. Short Circuit Current Rating: Switchboards shall be rated with a minimum short circuit current per the short circuit study.

E. Future Provisions: All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

F. Enclosure: Type 1 - General Purpose.

1. Sections shall be aligned front and rear.

2. Removable steel base channels (1½" floor sills) shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.

3. The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be a medium gray, ANSI #49, applied by the electro-deposition process over an iron phosphate pre-treatment.

4. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.

5. Top and bottom conduit areas shall be clearly indicated on shop drawings.

G. Nameplates: Provide one inch (1”) high x 3” engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.

H. Bus Composition: Shall be copper with silver plating. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown in the plans. For 4-wire systems, the neutral shall be of equivalent ampacity as the phase bus bar. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions, fully insulated without reducing the spacing of the bus and braced for short circuit currents. Furnish
continuous current rating as indicated on Drawings.

I. Bus Connections: Shall be bolted with Grade 5 bolts and conical spring washers, accessible from front or rear for maintenance (See drawings).

J. Ground Bus: Insulated sized per NFPA70 and UL 891 Tables 25.1 and 25.2, extend length of switchboard.

2.3 SWITCHBOARD - INCOMING MAIN SECTION DEVICES

A. Incoming Cable Lugs

1. Incoming conductors shall terminate at lug landing pads rated at 800A.

2. All lugs shall be UL Listed to accept solid and/or stranded copper and aluminum conductors. Lugs shall be suitable for 90° C rated wire according to the 90° C temperature rating in the NEC.

3. Provide mechanical type lugs to accommodate the conductor shown on the associated drawings.

2.4 SWITCHBOARD - DISTRIBUTION SECTION DEVICES

A. Group mounted circuit breakers through 800A

1. Circuit breaker(s) shall be group mounted plug-on with mechanical restraint on a common pan or rail assembly.

2. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.

3. Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.

4. Line-side circuit breaker connections are to be jaw type.

5. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

B. Current Limiter: Designed for application with molded case circuit breaker.

1. Coordinate limiter size with trip rating of circuit breaker to prevent nuisance tripping and to achieve interrupting current rating specified for circuit breaker.

2. Interlocks trip circuit breaker and prevent closing circuit breaker when limiter compartment cover is removed or when one or more limiter is not in place or has operated.

C. Thermal magnetic molded case circuit breakers

1. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.

2. Circuit protective devices shall be Square D molded or approved equal case circuit breaker(s). Circuit breaker(s) shall be high interrupting true current limiting*. Ampere ratings shall be as
shown on the drawings.

2.5 Manufacturer shall submit one set of published Ip and I²t let-through curves (as required by UL) to the owner.
   
   A. Thermal magnetic molded case circuit breaker(s) through 800A
      1. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
      2. Circuit protective devices shall be Square D molded case circuit breaker(s). Circuit breaker(s) shall be high interrupting true current limiting. Ampere ratings shall be as shown on the drawings.
      3. Manufacturer shall submit one set of published Ip and I²t let-through.

2.6 METERING

   A. Manufacturers:
      1. Square D Model PM 850RD with Square D PM80 Remote Display.

   B. The switchboard shall be metered using:
      1. Square D Type PM 850RD Digital Power Meter with 0.25% accuracy with the following features: A, V, kW, kVAR, kVAr, PF, F, kWh, kWArh, kVArh, KYZ, RS-485 communications, THD, Demand, kWd, kVARd, kVAd, date/time stamping. Each feeder breaker shall be individually metered.
      4. Include communication module required for connection to SFO central monitoring system.

2.7 SOURCE QUALITY CONTROL

   A. Furnish shop inspection and testing in accordance with NEMA PB 2.

   B. Make completed switchboard available for inspection at manufacturer's factory prior to packaging for shipment. Notify Project Manager/Engineer at least seven days before inspection is allowed.

   C. Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify Project Manager/Engineer at least seven days before inspections and tests are scheduled.

PART 3 – EXECUTION

3.1 EXAMINATION

   A. Division 1 General Requirements pertaining to Job Site Administrative.

   B. Verify surface is suitable for switchboard installation.

3.2 EXISTING WORK

   A. Disconnect and remove abandoned switchboards.
B. Maintain access to existing switchboards and other installations remaining active.

C. Clean and repair existing switchboards to remain or to be reinstalled.

3.3 INSTALLATION

A. Install in accordance with NEMA PB 2.1, manufacturer’s written guidelines, the NEC, and local codes.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

C. Install engraved plastic nameplates in accordance with Division 26 – Electrical Identification.

D. Install breaker circuit directory.

E. Ground and bond switchboards in accordance with Division 26 – Grounding and Bonding.

3.4 FIELD QUALITY CONTROL

A. Division 1 General Requirements - Quality Control; and Facility Startup: Field inspecting, testing, adjusting, and balancing.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.1.

D. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

E. Measure, using a Megger, the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute each, at minimum test voltage of 1000 VDC; minimum acceptable value for insulation resistance is 1 megohms. NOTE: Refer to manufacturer’s literature for specific testing procedures.

F. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer’s recommended torque values.

G. Physically test key interlock systems to check for proper functionality.

H. Test ground fault systems by operating push-to-test button.

3.5 INSPECTION

A. Examine area to receive switchboard to provide adequate clearance for switchboard installation.

B. Check that concrete pads are level and free of irregularities.

C. Start work only after unsatisfactory conditions are corrected.

3.6 ADJUSTING


B. Adjust operating mechanisms for free mechanical movement.
C. Tighten bolted bus connections.

D. Adjust circuit breaker trip and time delay settings to values.

3.7 CLEANING

A. Division 1 General Requirements – Contract Closeout: Final cleaning.

B. Touch up scratched or marred surfaces to match original finish.

END OF SECTION 26 24 13
SECTION 26 24 16 – PANELBOARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions and Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION

A. Work included in this Section: Panelboards.

B. Related work included in other Sections:
   1. Basic Construction Materials and Methods: Division 26.

1.3 INCORPORATED DOCUMENTS:

A. Division 26 – Electrical General Provisions, applies to all work in this Section.

1.4 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.5 DEFINITIONS

A. SVR: Suppressed voltage rating.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   1. 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.”

1.7 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes. Manufacturer’s Literature describing the product and shop drawings.

B. Shop Drawings: For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Short-circuit current rating of panelboards and overcurrent protective devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

6. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.” Include the following for units in excess of 400 pounds:

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.

E. 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.

F. Panelboard Schedules: For installation in panelboards.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section “Operation and Maintenance Data,” include the following:

1. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.
1. Testing Agency’s Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above panelboards is complete. Store in a protected environment prior to installation.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 23 °F to plus 104 °F.
   b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet.

1.11 COORDINATION

A. Coordinate layout and installation of panelboards 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. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.12 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

1.13 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

PART 2 – PRODUCTS

2.1 GENERAL CLASSIFICATION

A. Manufacturers: General Electric Company Catalog numbers are used to identify type of equipment specified. Equivalent products by Square D, Siemens-ITE or Cutler Hammer are acceptable.

B. Branch Circuit Panels:
   1. 277/480 volt: G.E. Type AE.
   2. 120/208 volt: G.E. Type AQ.

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”

B. Enclosures: Flush- and surface-mounted cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 4.
      d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.


C. Incoming Mains Location: Top or bottom.

D. Phase, Neutral, and Ground Buses:
   1. Material: copper only, minimum 98% conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box. Copper ground bus only.

3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.

E. Conductor Connectors: Suitable for use with conductor material and sizes.
   1. Material: Copper only, minimum 98% conductivity.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
   4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.


2.3 DISTRIBUTION PANELBOARDS

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 Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Dead-front, dead-rear, NEMA I or 3R (gasketed, weatherproof) enclosure, as indicated, designed for use on a three-phase, four wire, 120/208 volt system or 277/480V system. See drawings for additional details.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36" high, provide two latches, keyed alike.

E. Mains: Circuit breaker.


G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

H. Construction: Code gauge galvanized steel fully flanged for strength and rigidity. Door and trim shall
be cold-rolled steel, code gauge. Provide concealed butt hinges and 3-point catch and lock. Provide separately hinged or bolted vertical access doors over lug and wiring spaces.

I. Finish: Finish all exposed parts with one coat rust inhibitor and two coats of light grey enamel.

J. Bus Bars: Shall be installed throughout and shall be hard-rolled, electrolytic copper of 98% conductivity designed for a maximum 1000 amperes per square inch. Bars shall be factory pre-drilled to accept future field installation of 2 or 3 pole circuit breakers or fused switches in any combination, and shall run full length of breaker or switch space. Brace all bus bars for maximum short circuit rating of circuit breakers, but in no case less than 42,000 amperes symmetrical.

K. Provide ½ capacity ground bus with terminal lugs for each feeder shown.

L. Circuit Breaker Type: Thermal magnetic trip, molded case type breakers. Unless otherwise stated on the drawings the minimum interrupting capacity shall be 42,000 amperes symmetrical.

M. Provide handle locking devices for all circuit breakers.

N. Provide engraved bakelite nameplates with minimum ¼" high letters screwed to panel front and for each circuit protective device in panel adhesives not permitted.

O. Provide factory installed surge suppression system “TVSS” with capability to dissipate minimum of 240,000 surge current in less than 1 nanosecond response time, monitoring status display and visual/audible alarm and disconnect mean.

P. Distribution panelboards shall be 100% rated. Series rated panelboards are not acceptable

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.5 BRANCH CIRCUIT PANELBOARDS
A. Cabinet: Construct cabinet with code gauge galvanized steel. Provide minimum 20” wide cabinets and extra wiring space where incoming feed-through or parallel lines are shown.

B. Doors: Provide door-in-door construction, made of cold-rolled steel. Inner door shall provide access to breaker handles and outer door, access to wiring space as well. Inner door shall be completely flush with no visible bolts, screw-heads, or hinges and with flush catch and lock. Outer door shall have concealed hinges, flush catch and lock to match inner door, located in line with inner door catch. (Tee bar handles not acceptable). Secure top and bottom of outer door to cabinet by slotted head steel bolts. Release shall be by a one-half turn with a screw driver. All panels shall be keyed alike.

C. Flush mounted panels located adjacent to each other shall have identically sized enclosures and trims.

D. Finish: Finish exposed parts with one coat of primer and one coat of light grey enamel suitable for overpainting in field if desired.

E. Bus Bars:
   1. Bus Bars shall be silver plated copper sized at 1000 amps per square inch of cross. Attach circuit breakers to bus in such a way that circuits 1, 3, and 5; 2, 4, and 6, or any 3 similarly numbered circuits form one 3-phase, 4-wire circuit.
   2. Provide all hardware for future breakers, identified on drawings as SPACES, or for the full length of usable bus, whichever is longer.
   3. Provide minimum 1/2 capacity ground bus with full complement of terminals in addition to insulated neutral bus.

F. Circuit Breakers:
   1. Branch Circuit Panelboards: Quick-make, quick-break, molded case bolt-on type designed for three phase, four wire service with minimum of 22,000 amperes rms short circuit rating for 120/208 volt and a minimum of 65,000 amperes rms for 277/480 volt panels confirmed from the calculated short circuit study.
   2. Provide multi-pole units with common trip elements.
   3. Breakers shall have center-tripped position in addition of the ON and OFF positions.
   4. Provide lockouts for all circuits that should not be inadvertently turned off.

G. Nameplates: Provide screwed-on (no adhesives) engraved bake lite nameplate identification on outside of each panel showing panel designation voltage and phase in minimum 1/4” high letters.

H. Circuit Directories: Provide a metal-framed typed circuit directory welded to inside of inner door, with plastic protector.

I. Factory installed surge suppression system “TVSS” with capability to dissipate minimum 120,000 surge current in less than 1 nanosecond response time, monitoring status display and visual/audible alarm and disconnect mean.

J. Panelboards shall be 100% rated. Series rated panelboards are not acceptable.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES
A. Manufacturers:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.
   5. Or approved equal.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
      c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
      d. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75% of rated voltage.
      e. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

PART 3 – EXECUTION

3.1 EXAMINATION
   A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
   B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
   C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
   D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install panelboards and accessories according to NEMA PB 1.1.
   B. Housekeeping Pad: Install panelboards on concrete bases, 4” nominal thickness. Comply with requirements for concrete base specified in Division 3 Section “Cast-in-Place Concrete.”
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to panelboards.

5. Attach panelboard to the vertical finished or structural surface behind the panelboard. Temporary blocking of moving parts from panelboards.

C. Comply with mounting and anchoring requirements specified in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. Stub four 1” empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
   1. Comply with NECA 1.

I. All panelboards and similar equipment in finished public areas shall be flushed mounted. One ¾-inch empty conduit shall be stubbed up into an accessible furred space from panelboard for each six spare 20Amp circuit breakers or single pole spaces.

J. All flushed mounted equipment in finished public areas shall be finish painted to match surrounding wall or partition.

K. All panelboard face cover weighing more than 30 pounds shall be furnished with an angle support at bottom to carry weight of cover for assembly.

3.3 CLEARANCES

A. Minimum code required clearances around panelboards must be maintained.

3.4 MOUNTING HEIGHT

A. Mount panelboards with center of top circuit breaker handle no higher than 6’-6” above finished floor. Mount flush mounted panelboards as indicated on architectural interior elevation drawings.

3.5 MOUNTING HARDWARE
A. Provide all necessary blocking, channels and other hardware for securing panelboards to wall, column or other parts of building structure.

3.6 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section “Identification for Electrical Systems.”

B. Create a dated directory to indicate installed circuit loads; incorporate Owner’s final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

D. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included
3.8 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section “Overcurrent Protective Device Coordination Study.”

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20% between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.9 PROTECTION

A. Protect equipment per manufacturer’s written instructions.
SECTION 26 25 00 – ENCLOSED BUS ASSEMBLIES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Feeder-bus assemblies.

1.3 DEFINITIONS

A. SPD: Surge Protection Device.

1.4 SUBMITTALS

A. Shop Drawings: For each type of bus assembly.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.

2. Indicate required clearances, method of field assembly, and location and size of each field connection.

3. Detail connections to switchgear, switchboards, transformers, and panelboards.

4. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
   a. Design Calculations: Calculate requirements for selecting seismic restraints.
   b. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.

2. Clearances for access above and to the side of enclosed bus assemblies.

3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.

4. Support locations, type of support, and weight on each support.

B. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
C. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosed bus assemblies, accessories, and components will withstand seismic forces defined in Division 26 “Seismic Controls for Electrical Systems.” Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. 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.”
      b. 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. 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.

E. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29CFR 1910.7 and that is acceptable to authorities having jurisdiction.
   1. Testing Agency’s Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain enclosed bus assemblies through one source from a single manufacturer.

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

D. Comply with NEMA BU 1, “Busways.” F. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 140 °F (60 °C).

1.8 COORDINATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
B. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

2. General Electric Company; Electrical Distribution & Control Division.
4. Square D; Schneider Electric.

2.2 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.

1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Division 26 sections pertaining to “Seismic Controls for Electrical Systems” when mounting provisions and attachments are anchored to building structure
2. Voltage: 277/480 V; 3 phase; 100% neutral capacity.
4. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
5. Ground:
   a. 50% capacity integral with housing.
   b. 50% capacity internal bus bars of material matching bus material.
   c. 50% capacity isolated, internal bus bar of material matching bus material.
6. Enclosure: Steel with manufacturer’s standard finish.
7. Fittings and Accessories: Manufacturer’s standard.
8. Mounting: Arranged flat, edgewise, or vertically without derating

PART 3 – EXECUTION

3.1 INSTALLATION

A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division – 26 “Seismic Controls for Electrical Systems.”
2. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.

3. Support bus assembly to prevent twisting from eccentric loading.

4. Support bus assembly with not less than 3/8” (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.

5. Fasten supports securely to building structure according to Division 26 – “Hangers and Supports for Electrical Systems.”

B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer’s recommended distance between fittings.

C. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations.

D. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

E. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

3.2 CONNECTIONS

A. Ground equipment according to Division 26 - “Grounding and Bonding for Electrical Systems.”

B. Connect wiring according to Division 26 - “Low-Voltage Electrical Power Conductors and Cables.”

3.3 FIELD QUALITY CONTROL

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

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests and inspections and retest as specified above.
F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of bus assembly including joints and plug-in units.

1. Use an infrared scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed “Satisfactory Test” label to tested component.

3.4 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings as indicated.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.6 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 26 25 00
SECTION 26 27 13 – ELECTRICITY METERING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings, documents, and general provisions of the Contract, including but not limited to General
      Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes equipment for electricity metering by Owner.

1.3 DEFINITIONS
   A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of
      electricity that is based on a relay opening and closing in response to the rotation of the disk in the
      meter.
   B. PC: Personal computer.

1.4 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Shop Drawings: For electricity-metering equipment.
      1. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring
         designations and color-codes to facilitate installation, operation, and maintenance. Indicate
         recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show
         circuit protection features.
   C. Field Quality-Control Reports
   D. Operation and Maintenance Data. In addition to items specified in Division 1 Section “Operation and
      Maintenance Data,” include the following:
      1. Application and operating software documentation.
      2. Software licenses.
      3. Software service agreement.
      4. Hard copies of manufacturer’s operating specifications, design user’s guides for software and
         hardware, and PDF files on CD-ROM of the hard-copy Submittal.

1.5 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a
      qualified testing agency, and marked for intended location and application.
1.6 DELIVERY, STORAGE, AND HANDLING
A. Receive, store, and handle modular meter center according to NECA 400.

1.7 COORDINATION
A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
   1. Comply with requirements of utilities providing electrical power services.
   2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.8 SOFTWARE SERVICE AGREEMENT
A. Technical Support: Beginning with project completion, provide software support for two years.
B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade his computer equipment if necessary.

PART 2 – PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY OWNER
A. Manufacturers:
   1. Square D; a brand of Schneider Electric.
B. General Requirements for Owner’s Meters:
   1. Comply with UL 1244.
   2. Meters shall have an accuracy of 0.2% of reading, complying with requirements in ANSI C12.20.
   3. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.
   4. Identification: Comply with requirements in Division 26 Section “Identification for Electrical Systems.”
   5. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
   6. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
      a. Type: Split and solid core.
   7. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
8. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

C. Kilowatt-hour Meter: Electronic single- and three-phase meters, measuring electricity used.
   1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
   2. Display: LCD with characters not less than 0.25 inch high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.
   3. Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.

D. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section “Control-Voltage Electrical Power Cables.”

E. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation.
   1. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:
      a. At least 2 buildings.
   2. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters per manufacturer requirements. Install raceways and equipment according to owner’s written requirements. Provide empty conduits for metering leads and extend grounding connections as required by owner.

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

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

B. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.

C. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card with occupant’s name.

3.3 FIELD QUALITY CONTROL
A. Tests and Inspections:
1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

B. Electricity metering will be considered defective if it does not pass tests and inspections. Prepare test and inspection reports.

END OF SECTION 26 27 13
SECTION 26 27 16 – CABINETS AND ENCLOSURES

PART 1 – GENERAL

1.1 SUMMARY
A. Section includes hinged cover enclosures, cabinets, terminal blocks and accessories.

1.2 REFERENCES
A. National Electrical Manufacturers Association:
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA ICS 4 - Industrial Control and Systems: Terminal Blocks.
B. NECA Standard of Installation (National Electrical Contractors Association).
C. NFPA 70 - National Electrical Code.

1.3 RELATED SECTIONS
A. Division 26 Section – Electrical Hangers and Supports.
B. Division 26 Section – Grounding and Bonding

1.4 REGULATORY REQUIREMENTS
A. Conform to requirements of NFPA 70.
B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated

1.5 SUBMITTALS
A. Division 1 Section – Submittals.
B. Product Data: Submit manufacturer’s standard data for enclosures, and cabinets.
C. Manufacturer’s Installation Instructions: Submit application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum five years documented experience.

1.7 EXTRA MATERIALS
A. Division 1 Section – Contract Closeout.

B. Furnish two of each key.

PART 2 – PRODUCTS

2.1 HINGED COVER ENCLOSURES

A. Manufacturers:
   1. Hoffman
   2. Carlon Electrical Products
   3. Hubbell Wiring Devices
   4. Reliance Electric
   5. Or approved equal

B. Construction: NEMA 250, Type 1-indoor, 3R, 4 and 12 galvanized steel – outdoor enclosures or as specifically noted on drawings.

C. Covers: Continuous hinge, held closed by flush latch operable by key, unless otherwise noted.

D. Furnish interior metal or insulation panel for mounting terminal blocks and electrical components; finish with white enamel.

E. Enclosure Finish: Manufacturer’s standard enamel.

2.2 CABINETS

A. Manufacturers:
   1. Hoffman
   2. Carlon Electrical Products
   3. Hubbell Wiring Devices
   4. Reliance Electric
   5. Or approved equal

B. Boxes: Galvanized steel or as noted on plans.

C. Box Size: Size per NEC or as shown on plans.

D. Fronts: Galvanized Steel, flush or surface type with concealed trim clamps, door with concealed hinge, and flush lock keyed to match branch circuit panelboard. Finish with gray baked enamel.

E. Knockouts sized to fit incoming/outgoing conduits.

F. Furnish metal barriers to form separate compartments wiring of different systems and voltages.

G. Furnish accessory feet for free-standing equipment.

2.3 TERMINAL BLOCKS
A. Manufacturers:
   1. Carlon Electrical Products
   2. Hubbell Wiring Devices
   3. Reliance Electric Model
   4. Or approved equal

B. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.

C. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts.

D. Furnish ground bus terminal block, with each connector bonded to enclosure.

PART 3 – EXECUTION

3.1 EXISTING WORK

A. Remove abandoned cabinets and enclosures. Patch surfaces.

B. Maintain access to existing cabinets and enclosures and other installations remaining active and requiring access. Modify installation or provide access panel.

C. Extend existing cabinets and enclosures using materials and methods compatible with existing electrical installations or as specified if applicable.

D. Clean and repair existing cabinets and enclosures to remain or to be reinstalled.

3.2 INSTALLATION

A. Install enclosures and boxes plumb. Anchor securely to wall and structural supports at each corner.

B. Install cabinet fronts plumb.

3.3 CLEANING

A. Division 1 Section – Contract Closeout.

B. Clean electrical parts to remove conductive and harmful materials.

C. Remove dirt and debris from enclosure.

D. Clean finishes and touch up damage.

END OF SECTION 26 27 16
SECTION 26 27 26 – WIRING DEVICES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provisions: Applicable provisions of Division 26 Sections – General Electrical Requirements and Basic Materials and Methods become a part of this Section as if repeated herein.

B. Work Included:

1. Installation, connection and furnishing all single, duplex, and special purpose receptacles complete with wall plates and/or covers as shown on the Drawings.

2. Installation, connection and furnishing of all single pole, three-way, pilot light and momentary position toggle switches complete with wall plates and or handle operators as shown on the Drawings.

C. Related Work Described Elsewhere:

1. Low-Voltage Wire and Cable: Division 26 Section
2. Conduit, Raceway and Fittings: Division 26 Section
3. Or other work as shown in drawings.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:

1. C73-1973 Plugs and Receptacles
2. C73a-1980 Plugs and Receptacles

B. Federal Specifications (FS):

1. W-C596 D&E General Specifications for Cable Outlet Electrical Connector
2. W-S-896 D&E General Specifications for Flush Mounted Toggle and Lock Switches
3. W-P-4552 General Specifications for Surface Mounted Wall Plates

C. National Electrical Manufacturers Association (NEMA) Publications:

1. WD 1-1979 General Purpose Wiring Devices
2. WD 3-1972 Alternating Current General-Use Snap Switches
3. (R1977) Specific Purpose Wiring Devices
4. WD 5-1977 Specific Purpose Wiring Devices

D. Underwriters Laboratories (UL) Standards:

1. 20-1986 General-Use Snap Switches
2. 498-1986 Electrical Attachment Plugs and Receptacles
3. 514-1987 Electrical Outlet Boxes
1.3 SUBMITTALS

A. Submit manufacturers published descriptive literature properly marked to identify the items to be supplied.

B. A single complete submittal is required for all products covered by this Section.

1.4 LOCATIONS

A. Refer to Division 26 Section, GENERAL ELECTRICAL REQUIREMENTS, for definitions of types of locations.

PART 2 – PRODUCTS

2.1 RECEPTACLES

A. General: All receptacles shall be heavy duty, high abuse, conforming to NEMA configurations NEMA WD1 and UL 943 Standards.

B. Single and Duplex Receptacles:

1. Receptacles shall be of back and side wire design utilizing screw type terminals. Receptacles shall be rated 20 ampere, single-pole, 3-wire, 120 volt, NEMA 5-20 configuration. Power contacts shall be a T-type design and shall be brass. Ground contacts shall be brass.

2. Devices shall have a nylon composition face with a nylon or melamine body. Units shall comply with Federal Specification W-C596E and meet UL 498 test requirements. Receptacles shall be Hubbell 5352, Bryant 5362, or equal.

2.2 SWITCHES

A. Line Voltage Types: Switches shall be rated 20 amperes at 120 or 277 volts ac only. Units shall be flush-mounted, self-grounding, quiet operating toggle devices. Units shall conform to Federal Specifications W-S 896 D&E, UL 20, and NEMA WDI standards.

B. Related work described elsewhere:

1. Division 26 Sections – Lighting

2. Other work as shown in electrical drawings.

2.3 PLATES

A. General: Plates shall be of the style and color to match the wiring devices, and of the required number of gangs. Plates shall conform to NEMA WDI, UL 514, ANSI C73, and FS W-P-4552. Plates on finished walls shall be non-metallic or stainless steel. Plates on unfinished walls and on fittings shall be of zinc plated steel or cast metal having rounded corners and beveled edges.

B. Non-Metallic: Plates shall be plain with beveled edges and shall be nylon or reinforced fiberglass.
C. Stainless Steel: Plates shall be .040” thick with beveled edges and shall be manufactured from No. 430 alloy having a brushed or satin finish.

D. Galvanized: Plates shall be galvanized sheet steel raised 1/2-inch, with rounded corners.

E. Cast Metal: Plates shall be cast or malleable iron covers with gaskets so as to be moisture resistant or weatherproof.

F. Blank Plates: Cover plates for future telephone or television outlets shall match adjacent device wall plates in appearance.

G. Outdoor Locations: Plates shall have weather protective snap covers. Covers shall be die cast aluminum for metallic plates or nylon for non-metallic plates.

PART 3 – EXECUTION

3.1 INSTALLATION OF WIRING DEVICES

A. Dry Locations: The device shall be installed in surface mounted boxes with washers as required.

B. Damp or Wet Exterior Locations: Install only wiring devices approved for outdoor service in these locations.

C. Mounting Heights: Locations of wall outlets shall be measured from the finished floor to the center of the outlet box. Boxes shall be adjusted so that the front edge of the box shall not be further back from the finished wall plane than 1/8 -inch. Boxes shall be adjusted so that they do not project beyond the finished wall. Height above finished floor shall be as follows unless otherwise noted:

<table>
<thead>
<tr>
<th>Inches from Floor</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Telephone Outlets</td>
<td>18</td>
</tr>
<tr>
<td>Duplex Receptacles</td>
<td>18</td>
</tr>
<tr>
<td>Light Switches</td>
<td>42</td>
</tr>
</tbody>
</table>

D. Damp or Wet Interior Locations: Install only wiring devices approved for outdoor service. Adjust boxes so that from edge will be no more than 1/8-inch behind the front edge of the finished wall. Use metal tubing sleeves to bring device mounting straps flush with the front edge of the finished wall.

E. Receptacles:
   1. Receptacles shall be grounded by a grounding conductor, not by a yoke or screw contact.
   2. Receptacles shall be oriented so that the grounding slot is located at the top of the outlet.
   3. Receptacles shall be installed with connections pigtailed (spliced) to the branch circuit wiring so that removal of the receptacle will not lose neutral continuity and branch circuit power will not be lost to other receptacles on the same circuit.

3.2 INSTALLATION OF WALL PLATES

A. General: Plates shall match the style of the device and shall be plumb within 1/16-inch of the vertical or horizontal.
B. Interior Dry Locations: Install plates so that all four edges are in continuous contact with the finished wall surfaces. Plaster filling will not be permitted. Do not use oversize plates or sectional plates.

C. Exterior and/or Wet Locations: Install plates with gaskets on wiring devices in such a manner as to provide a raintight weatherproof installation. Cover type shall match box type.

D. Future Locations: Install blanking cover plates on all unused outlets.

3.3 TESTS

A. Receptacles:
   1. Receptacles shall be tested for blade and ground plug tension prior to installation. Do not install any receptacle having less than 16 oz. individual brace retention.
   2. After installation of receptacles, circuits shall be energized and each receptacle tested for proper ground continuity, reversed polarity, and/or open neutral condition.

END OF SECTION 26 27 25
SECTION 26 28 00 – SWITCHES AND CIRCUIT BREAKERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. The Contractor shall furnish and install the molded case circuit breakers and switches having the electrical characteristics, ratings and modifications as specified herein and as shown on the contract drawings.

1.2 REFERENCES

A. The molded case circuit breakers and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of the following:

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>UL 489</td>
<td>Molded Case Circuit Breakers</td>
</tr>
<tr>
<td>2.</td>
<td>NEMA AB1</td>
<td>Molded Case Circuit Breakers</td>
</tr>
<tr>
<td>3.</td>
<td>NEMA 250</td>
<td>Enclosures for Electrical Equipment</td>
</tr>
<tr>
<td>4.</td>
<td>NEMA KS 1</td>
<td>Enclosed and Miscellaneous Distribution Equipment Switches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(600 Volts Maximum).</td>
</tr>
<tr>
<td>5.</td>
<td>ANSI-C33.64</td>
<td>Safety Standard for Enclosed Switch</td>
</tr>
<tr>
<td>6.</td>
<td>UL-98</td>
<td>Safety Standards for Enclosed Switch</td>
</tr>
<tr>
<td>7.</td>
<td>NEMA FU 1</td>
<td>Low Voltage Cartridge Fuses</td>
</tr>
</tbody>
</table>

B. International Electrical Testing Association:


1.3 SUBMITTALS

A. The following information shall be submitted to the Engineer.

1. Master drawing index.
2. Dimension sheet.
3. Accessory information.
4. Device ratings.
   a. Voltage.
   b. Continuous current.
   c. Interrupting ratings.
   d. Cable terminal sizes.

B. Submit one (1) hard copy and one (1) electronic copy of the above information.
1.4 SUBMITTALS – FOR INFORMATION
   A. When requested by the Engineer the following product information shall be submitted:
      1. Descriptive bulletins.
      2. Product sheets.

1.5 SUBMITTALS – FOR CLOSEOUT
   A. The following information shall be submitted for record purposes prior to final payment.
      1. Final as-built drawings and information for items listed in Article 1.4.

1.6 QUALIFICATIONS
   A. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.
   B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.7 REGULATORY REQUIREMENTS
   A. Circuit breakers shall be Underwriters Laboratories listed and conform to the requirements of Federal Specification W-C-375a.

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.

1.9 OPERATION AND MAINTENANCE MANUALS
   A. Submit one (1) hard copy and one (1) electronic copy of the equipment operation and maintenance manuals shall be provided prior to final payment.
   B. Operation and maintenance manuals shall include the following information:
      1. Instruction books and/or leaflets.
      2. Recommended renewal parts list.
      3. Drawings and information required by Article 1.3.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
   A. Square D
   B. Eaton/Cutler-Hammer
   C. Or approved equal

2.2 MOLDED CASE CIRCUIT BREAKERS
A. Molded case circuit breakers shall provide circuit overcurrent protection with inverse time and
instantaneous tripping characteristics and shall be Square D, Cutler-Hammer/Westinghouse or
approved equal.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break
over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker
shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy, and arc
extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front
of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

D. Where indicated, circuit breakers shall be UL listed for series application.

E. Where indicated, circuit breakers shall be current limiting.

F. Circuit breakers 400 ampere frame and below shall have thermal-magnetic trip units and inverse time-
current characteristics.

G. Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere
rating in their intended enclosure.

H. Field-Changeable Ampere Rating Circuit Breaker: Circuit breakers with frame sizes 200 amperes and
larger have changeable trip units.

I. Current Limiting Circuit Breaker: Circuit breaker indicated as current-limiting have automatically-
resetting current limiting elements in each pole. Let-through Current and Energy: Less than permitted
for same size Class RK-5 fuse.

J. Solid-State Circuit Breaker: Electronic sensing, timing, and tripping circuits for adjustable current
settings; ground fault trip with integral ground fault sensing; instantaneous trip; and adjustable short
time trip.

K. Circuit breaker serving HVAC rated loads shall be HVAC type. Circuit breaker serving other motor loads
shall be motor.

2.3 ACCESSORIES

A. Provide ground fault protection as shown on the contract drawings.

2.4 ENCLOSURES

A. All enclosed circuit breakers shall have NEMA 1 general purpose enclosures unless otherwise noted.
Provide enclosures suitable for locations as indicated on the drawings and as described below.

1. NEMA 1 surface or flush-mounted general purpose enclosures primarily intended for indoor use.

2. NEMA 12 dust-tight enclosures intended for indoor use primarily to provide protection against
circulating dust, falling dirt, and dripping non-corrosive liquids.

3. NEMA 3R rain-tight enclosures intended for outdoor use primarily to provide protection against
rain, sleet, and damage from external ice formation.
4. NEMA 4 rain-tight enclosures intended for outdoor use primarily to provide protection against rain, sleet, splashing water, hose directed water, and damage from external ice formation.

5. NEMA 4X watertight stainless steel intended for indoor or outdoor use primarily to provide protection against windblown dust and rain, splashing rain, hose-directed water, corrosion, and damage from external ice formation.

6. NEMA 7, Class I, Group D hazardous location cast aluminum intended for indoor use in locations classified as Class I, Group D as defined in the National Electrical Code.

7. NEMA 9, Class II, Groups E, F, G hazardous location cast aluminum intended for indoor use in locations classified as Class II, Groups E, F, and G as defined in the National Electrical Code.

B. All enclosed circuit breakers shall have metal nameplates, front cover mounted, that contain a permanent record of catalog number and maximum rating. Provide handle mechanisms that are padlockable in the "OFF" position.

2.5 DISCONNECT SWITCHES

A. Disconnect switches shall be NEMA KS 1, heavy-duty (HD) with externally operable handle interlocked to prevent opening front cover with switch in ON position enclosed load interrupter knife switch. Handle lockable in OFF position, fusible type unless non-fusible type with number of poles required to disconnect ungrounded conductors as indicated on the Drawings. When exposed to weather, enclosure shall be NEMA 4.

B. Disconnect switches for 3-phase motor rated 2-horsepower or less shall be 3-pole, 600-volt motor switches with overload protection.

C. Disconnect switches for 3-phase motors rated above 2-horsepower shall be 600-volt heavy duty safety switches HP rated for AC or DC as shown on the Drawings.

D. Short Circuit Current Rating: UL listed for 10,000 rms symmetrical amperes when used with or protected by Class H or K fuses (30-600 ampere), 200,000 rms symmetrical amperes when used with or protected by Class R or Class J fuses (30-600 ampere switches employing appropriate fuse rejection schemes).

PART 3 – EXECUTION

3.1 EXISTING WORK

A. Disconnect and remove abandoned enclosed circuit breakers and enclosed switches.

B. Maintain access to existing enclosed circuit breakers, enclosed switches and other installations remaining active and requiring access. Modify installation or provide access panel.

C. Clean and repair existing enclosed circuit breakers and enclosed to remain or to be reinstalled.

3.2 FACTORY TESTING

A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NETA ATS and UL standards.
3.3 INSTALLATION
   A. The Contractors shall install all equipment per the manufacturer’s recommendations and the contract drawings.
   B. Install enclosed circuit breakers plumb. Provide supports in accordance with Division 26 Section – “Electrical Hangers and Supports”.
   C. Install fuses for fusible disconnect switches.
   D. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.
   E. Locate and install engraved plastic nameplates in accordance with Division 26 Section – “Electrical Identification.”

3.4 FIELD QUALITY CONTROL
   A. Division 1 Sections – Quality Control: Testing and Inspection Services; and Contract Closeout: Testing, adjusting, and balancing.
   B. Inspect and test in accordance with NETA ATS, except Section 4. Perform inspections and tests listed in NETA ATS, Section 7.6.1.1.

3.5 FIELD SETTINGS
   A. The Contractor shall perform field adjustments of the circuit breakers as required to place the equipment in final operating condition. The settings shall be in accordance with the approved protective device coordination study or as directed by the Engineer.

3.6 ADJUSTING
   A. Division 1 Section – Contract Closeout: Testing, adjusting, and balancing.
   B. Adjust trip settings to coordinate circuit breakers with other overcurrent protective devices in circuit.
   C. Adjust trip settings to provide adequate protection from overcurrent and fault currents.

3.7 DISCONNECT SWITCHES
   A. Fusible/Non-fusible disconnect switches shall be provided for motors located out of sight of motor controller and where indicated on the Drawings. Switches shall be installed to be readily accessible, and with working space required by Article 110-26 of the National Electrical Code with required support.
   B. Identify disconnect switches in accordance with “Equipment Identification” paragraph of this Division of the Specifications.

END OF SECTION 26 28 00
PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, and enclosed controllers.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer’s technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer’s technical data on features, performance, electrical characteristics, and ratings.


4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

5. Coordination charts and tables and related data.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section “Operation and Maintenance Data,” include the following:

1. Ambient temperature adjustment information.

2. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

3. Coordination charts and tables and related data.

1.4 QUALITY ASSURANCE
A. **Source Limitations:** Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

### 1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 °F or more than 100 °F, apply manufacturer’s ambient temperature adjustment factors to fuse ratings.

### 1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

### 1.7 EXTRA MATERIALS

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

1. **Fuses:** Equal to 10% of quantity installed for each size and type, but no fewer than two of each size and type.

### PART 2 – PRODUCTS

#### 2.1 MANUFACTURERS

A. Manufacturers:

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.
5. Or approved equal.

#### 2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

### PART 3 – EXECUTION

#### 3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

A. FUSE APPLICATIONS

1. Cartridge Fuses:
2. Motor Branch Circuits: Class RK5, time delay.
3. Other Branch Circuits: Class RK1, time delay.
4. Control Circuits: Class CC, fast acting.

3.3 INSTALLATION

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

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems” and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13
SECTION 26 28 16 – ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Enclosures.

1.3 DEFINITIONS
A. NC: Normally closed.
B. NO: Normally open.
C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS
A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. 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.”

1.5 SUBMITTALS
A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of NRTL listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
B. 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.

C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section “Operation and Maintenance Data,” include the following:
   1. Manufacturer’s written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.
   1. Testing Agency’s Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. 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.

E. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 °F and not exceeding 104 °F.
   2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 – PRODUCTS

2.1 FUSIBLE 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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Auxiliary Contact Kit: One NO/NC (Form “C”) auxiliary contact(s), arranged to activate before switch blades open.
   3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE 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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Auxiliary Contact Kit: One NO/NC (Form “C”) auxiliary contact(s), arranged to activate before switch blades open.
   3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES
A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 4.
   4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 – EXECUTION
3.1 EXAMINATION
A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
B. Comply with mounting and anchoring requirements specified in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”
C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
D. Install fuses in fusible devices.
E. Comply with NECA 1.

3.3 IDENTIFICATION
A. Comply with requirements in Division 26 Section “Identification for Electrical Systems.”
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
      b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

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

END OF SECTION 26 28 16
APPENDIX A – MASTER LIST OF MANUFACTURERS

This section provides the Master List of Manufacturers approved for Electrical Substations and Transformers approved by SFO organized by section and subsection. Contractors are responsible for any extra cost incurred when evaluating products by manufacturers that are not listed are approved equals.

26 11 16 – SECONDARY UNIT SUBSTATIONS

1. Square D; Schneider Electric.

26 13 13 – MEDIUM-VOLTAGE SWITCHGEAR

1. METAL-CLAD, CIRCUIT-BREAKER SWITCHGEAR
2. Eaton Corporation; Cutler-Hammer Products.
3. Square D; Schneider Electric.

26 22 00 – LOW-VOLTAGE TRANSFORMERS

1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Controlled Power company.
5. General Electric Company.
8. Micron Industries Corp.
9. Myers Power Products, Inc.
10. Siemens Energy & Automation, Inc.
12. Square D; Schneider Electric.

26 24 13 – SWITCHBOARDS

METERING:
1. Square D Model PM 850RD with Square D PM80 Remote Display.

TRANSIENT VOLTAGE SUPPRESSION DEVICES:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

26 24 16 – PANELBOARDS

DISTRIBUTION PANELBOARDS:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.
LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

26 25 00 – ENCLOSED BUS ASSEMBLIES

2. General Electric Company; Electrical Distribution & Control Division.
4. Square D; Schneider Electric.

26 27 13 - ELECTRICITY METERING

1. EQUIPMENT FOR ELECTRICITY METERING BY OWNER
2. Square D; a brand of Schneider Electric.

26 27 26 - WIRING DEVICES

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper)
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour)

POKE-THROUGH ASSEMBLIES

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
3. Square D/ Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold Company (The).

MULTI-OUTLET ASSEMBLIES

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold Company (The).

26 28 13 – FUSES

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littlefuse, Inc.

26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS
FUSIBLE SWITCHES
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

NON-FUSIBLE SWITCHES
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.
Standards Adoption

The “Electrical – Substations & Transformers” Version 3.1, April 2018 A&E Standards were adopted by the Standards Committee on May 3rd, 2018, and are effective immediately.

Confirmed:

[Signature]

Geoffrey W. Neumayr, Standards Committee Chair