SECTION 262300 - LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes metal-enclosed, low-voltage switchgear, with drawout power circuit breakers and metering and control accessories.

1. Switchgear structure.
2. Requirements for indoor switchgear.
3. Requirements for outdoor switchgear.
4. Circuit breakers.
5. Arc-flash limiting feeder circuit breakers.
6. Zone-selective interlocking.
7. Network protectors.
8. Surge suppression.
9. Control power supply, 120-V ac.
10. Control power supply, 24-V dc.
11. Instrumentation and control.
12. Maintenance tools.
13. Identification.
14. Source quality control.

B. Related Requirements:

1. Section 230923.13 "Energy Meters" for electricity meters for HVAC equipment.
2. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for submetering.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

C. Shop Drawings: For low-voltage switchgear.

1. System Power One-Line Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
   a. Frame size of each circuit breaker.
   b. Trip rating for each circuit breaker.
   c. Conduit and wire size for each feeder.

2. Include plans, elevations, sections, shipping splits, and mounting details.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Wire Termination Diagrams and Schedules: Include 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. Differentiate between manufacturer-installed and field-installed wiring.

5. Retain "Block Diagram" Subparagraph below if this Section includes PC-based local area data bus or link to equipment specified in Section 260913 "Electrical Power Monitoring and Control."

6. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

7. Indicate short-time and short-circuit current rating of switchgear assembly.

8. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. Include mimic-bus diagram.

D. Delegated-Design Submittal: For low-voltage switchgear.

1. Comply with Section 260572 "Overcurrent Protective Device Short-Circuit Study" and Section 260573.16 "Coordination Studies."

2. For the differential ground-fault protection scheme. Include wiring diagram of the differential system along with test procedure recommended by UL 1558, using high-current injection equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around the low-voltage switchgear where pipe and ducts are prohibited.

B. Coordinate "Qualification Data" Paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as may be supplemented in "Quality Assurance" Article.

C. Qualification Data: For testing agency.

D. Retain "Seismic Qualification Data" Paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 260548.16 "Seismic Controls for Electrical Systems." See ASCE/SEI 7 for certification requirements for equipment and components.

E. Seismic Qualification Data: Certificates, for switchgear, accessories, and components, from manufacturer.

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

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

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

F. Product Test Reports: Submit evidence that switchgear is compatible with connected monitoring and control devices and systems specified in Section 260913 "Electrical Power Monitoring and Control."

1. Show interconnecting signal and control wiring, and interface devices to show compatibility of meters.

2. For reporting and billing interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

G. Source quality-control reports.

H. Retain "Field quality-control reports" Paragraph below if Contractor is responsible for field quality-control testing and inspecting.

I. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Time-current curves (on full-size logarithmic paper) of the main secondary breaker and largest secondary feeder device.
b. Lists of spare parts and replacement components recommended for storage at Project site.
c. Detailed instructions covering operation under both normal and abnormal conditions.
d. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On USB media or compact disk, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every three of each type and rating, but no fewer than three of each for the following:
   a. Potential transformers.
   b. Control power circuits.

2. Drawout Circuit Breakers: One of each type and rating used for circuit breaker in the switchgear.

B. System Power Riser Diagram: For each switchgear, post on the wall at each location, using non-fugitive ink on high-quality paper.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

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

1.7 DELIVERY, STORAGE, AND HANDLING

A. Indoor Switchgear Storage: Store in a dry, clean location, placed on a level surface to prevent strain and possible distortion. During the construction period, provide protection against dust, dirt, falling objects, dripping water, water, excessive moisture, and other possible causes of damage to the equipment. Any temporary covering shall not restrict ventilation and may not be removed until the equipment is ready for installation. Store indoor equipment within a heated building. Take special precaution to keep the equipment sufficiently warm with adequate ventilation to prevent condensation during the storage period. Install temporary heating if necessary.

B. When provisions for temporary power connection are provided as part of the switchgear assembly, provisions shall be included to prevent energization of primary buses or connections by means of backfeed through fuses or control power transformers connected to the primary buses or connections.

C. If outdoor switchgear cannot be installed and energized, temporary power shall be provided for the operation of the space heaters provided so as to prevent condensation of moisture within the housing.

D. Ventilation openings shall be left open to permit proper air circulation.

1.8 FIELD CONDITIONS

A. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than minus 30 deg C and not exceeding 40 deg C.

2. Humidity Rating: Less than 95 percent (noncondensing).

3. Altitude Rating: Not exceeding 2000 m.

4. To determine whether solar radiation mentioned in first subparagraph below is significant, consult IEEE C37.24.

5. The effect of solar radiation is insignificant.

6. .

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Description: Metal-enclosed, low-voltage switchgear with drawout fused fused, where indicated, power circuit breakers, with accessories and metering components.

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

2. Comply with IEEE C37.20.1.

3. Listed and labeled as complying with UL 1558.

4. Listed and labeled for use as service entrance equipment.

2.3 PERFORMANCE REQUIREMENTS

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

1. The term "withstand" means "the assembly will remain in place without separation of any parts when subjected to the seismic forces specified and the assembly will be fully operational after the seismic event."

2. For life-safety components required to function after an earthquake, the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

3. Component Importance Factor: 1.5 1.0.

4. See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in subparagraph below.

5. .

B. Capacities and Characteristics:

1. Nominal System Voltage: 480 V, three 480/277 V, four 240 V, three 208/120 V, four wire, 60 Hz.

2. Rated Maximum Voltage: 254 508 635 V.

3. Rated Power Frequency: 60 Hz.

4. Rated Insulation Level: Power frequency withstand shall be not less than 2.2-kV rms.

5. Rated Continuous Current:
   a. Main-Bus Continuous: 1600 2000 3000 3200 4000 5000 A.
   b. Vertical Section Bus Riser: Equal to the frame size of the low-voltage power circuit breaker connected to that riser.

6. Rated Short-Circuit Withstand Current: 42,000 65,000 85,000 100,000 200,000 A symmetrical.

7. Short-Time and Short-Circuit Current: Match rating of integrated short-circuit current rating.

2.4 SWITCHGEAR STRUCTURE

A. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker. Extend section barriers between main and tie circuit breakers to the rear of the section.

B. Coordinate first paragraph below with Drawings.

C. Allow the following circuit-breaker functions to be performed when the compartment door is closed:

1. Operate manual charging system.

2. Open and close the circuit breaker.

3. Examine and adjust the trip unit.

4. Read the breaker nameplate.

D. Install instrument compartments when additional space is required for metering and instrumentation. Allow for routing of instrumentation, control and communications wires, and cables.

E. "Switchgear Bus" Paragraph below assumes that the secondary section consists of more than one vertical section. Revise if only one section is required. Coordinate below with Drawings.

F. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.

2. Main Phase Bus: Uniform capacity the entire length of assembly.

3. Neutral buses may be oversized to carry high neutral currents associated with significant nonlinear loads. However, there is no provision in IEEE and UL standards for the bus configurations necessary to accomplish this, and through-buses and vertical section buses with oversized neutrals are difficult to fabricate. A practical way to oversize the neutral bus is to select a higher switchgear rating. For example, a switchgear that requires a 2000-A main-bus rating for normal loading could be specified to have a main bus rated at 3200 A with a full-size neutral. This approach oversizes the neutral by 60 percent.

4. Neutral Bus: 50 100 percent of phase-bus ampacity unless otherwise indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.

5. Ground Bus: Uniform capacity the entire length of assembly, with pressure connector terminations for feeder and branch-circuit ground conductors, minimum size 6 by 50 mm.

6. Retain "Vertical Section Bus Size" Subparagraph below if switchgear assembly includes spare circuit breakers and spaces for future circuit breakers. IEEE C37.20.1 requires the vertical section bus capacity to be the lesser of the main-bus continuous-current rating or the allowable cumulative circuit-breaker loading, based on a table in the standard. The table gives a load figure for various combinations of frame sizes and numbers of circuit breakers in a section. This method usually results in conservative bus-size ratings.

7. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers Fully rated to the system continuous current, equal to the horizontal bus.

8. Retain "Bus Material and Connections" Subparagraph below when required by Project conditions.

9. Bus Material and Connections:
   a. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
   b. Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.
   c. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
   d. Retain one of first two subparagraphs below as required by bus-material specification.
   e. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
   f. Use copper for connecting circuit-breaker line to copper bus.
   g. Contact Surfaces of Buses: Silver plated.
   h. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

10. Neutral Disconnect Link: Bolted, uninsulated, bus, arranged to connect neutral bus to ground bus.

11. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

12. IEEE and UL standards may require air insulation only. Retain "Bus-Bar Insulation" Subparagraph below if insulated bus is required.

13. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
   a. Sprayed Insulation Thickness: 0.08 mm, minimum.
   b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

G. Circuit-Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, disconnected, and withdrawn positions. Include the following features:
   a. Provide circuit-breaker racking system with positive stops at connected, test, disconnected, and withdrawn positions.
   b. Interlocks: Prevent racking of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
   c. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from connected, test, and disconnected positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit manual withdrawal of an open circuit breaker to a position for removal from the structure. When compartment door is open, status for connection devices for different positions includes the following:
      1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
      2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
   d. Primary Disconnect: Mount on the stationary part of the compartment. Disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the connected position. Assembly shall

provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.

e. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of breaker.

f. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.

g. Place 2400-A frame and larger circuit breakers at the bottom of switchgear.

H. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:

1. Utility metering compartment that complies with utility-company requirements.

2. Coordinate first subparagraph below with Drawings. Pull sections are usually not required in low-voltage power switchgear. Metering provisions and main circuit-breaker connections may influence space available for incoming lines.

3. Bus transition sections.

4. Incoming-line pull sections.

5. Hinged front panels for access to metering, accessory, and blank compartments.

I. Pull Boxes: Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers and with ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.

1. Set pull box back from front to clear circuit-breaker lifting mechanism.

2. Pull-Box Bottom: Insulating, fire-resistant material with separate holes for cable drops into switchgear.

3. Cable Supports: Arranged to ease cabling and adequate to support cables, including those for future installation.

2.5 ADDITIONAL REQUIREMENTS FOR INDOOR SWITCHGEAR

A. Enclosure Rating: Indoor.

B. Enclosure Material: Steel.

C. Enclosure Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

D. Enclosure Rear Panels: Removable and hinged, to allow access to rear interior of switchgear.

2.6 ADDITIONAL REQUIREMENTS FOR OUTDOOR SWITCHGEAR

A. Outdoor Enclosure Rating: UL 1558.

B. Outdoor Enclosure Description: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating

C. Retain one of two options in "Outdoor Enclosure Material" Paragraph below, depending on corrosion protection requirements. Retain second option for increased corrosion resistance for locations such as waste-water treatment plants and environments that are subject to salt spray. Coordinate with retained "Outdoor Enclosure Finish" Paragraph.

D. Outdoor Enclosure Material: Steel 12-gage, ASTM A240, Type 304 or 304L stainless steel.

E. Retain one of three "Outdoor Enclosure Finish" paragraphs below, depending on Project requirements.

F. Outdoor Enclosure Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.

G. Outdoor Enclosure Finish: Factory-applied, corrosion-resistant finish in manufacturer's standard color that withstands 120 480 hours of exposure to salt-spray test specified in ASTM B117, without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm from the test mark. The scribed test mark and test evaluation shall be conducted according to ASTM D1654, with a rating of not less than 7 per Table 1 (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill-galvanized sheet steel shall be coated with a manufacturer's standard zinc-rich paint.

H. Outdoor Enclosure Finish: Front and rear doors shall be provided with stainless-steel padlockable vault handles with a three-point catch. Bases, frames, and channels of enclosure shall be corrosion resistant, fabricated of ASTM A240 Type 304 or 304L stainless steel. Base shall include any part of enclosure that is within 75 mm of the concrete pad. Coat enclosure, including bases, shall be ASTM D1535 light gray No. 61 or No. 49. Coating system shall comply with IEEE C57.12.29 for stainless steel.

I. Features:

1. Comply with locally adopted codes for gravity and wind loads. Structural design and anchorage adequate to resist loads imposed by 200-km/h wind.

2. Sloping, standing-seam type, insulated roof panels.

3. Mount each shipping group on an integral base frame as a complete weatherproof unit.

4. Aisle-Less Construction: Each vertical section shall have the following:
   a. Hinged front door with padlocking provisions.
   b. Interior light with switch.
   c. Weatherproof duplex receptacle.
   d. Retain first subparagraph below in very cold climates to minimize heat loss.
   e. With draft-stop where busway exits the vertical section.
   f. Indicate ventilation and heating equipment on Drawings, or revise "Vertical Section Space Conditioning" Subparagraph below to include outdoor design temperatures and humidity so that manufacturer can size conditioning equipment. Include redundant equipment to ensure operation of space conditioning during emergency conditions. Coordinate with "Ambient Environment Ratings" Paragraph in "Field Conditions" Article.
   g. Vertical Section Space Conditioning: Provide outside-air openings with insect and rodent screens and filters; arranged to permit air circulation while excluding insects, rodents, and exterior dust. Provide thermostatically controlled space heaters operating at one-half or less of rated voltage.

5. Common Internal Aisle-Type Construction:

a. With aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
b. Aisle access doors with outside padlocking provisions and interior panic latches.
c. Vaporproof LED aisle lights fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
d. GFCI duplex receptacles, a minimum of two, located in aisle.
e. Interior Space Conditioning: Aisle ventilation louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
f. Retain one of two "Interior Space Conditioning" subparagraphs below. Indicate ventilation and heating equipment on Drawings, or revise either subparagraph below to include outdoor design temperatures and humidity so that manufacturer can size conditioning equipment. Include redundant equipment to ensure operation of space conditioning during emergency conditions. Coordinate with "Ambient Environment Ratings" Paragraph in "Field Conditions" Article.
g. Interior Space Conditioning: Forced-air aisle ventilation with thermostatically controlled vent fans, interlocked with aisle space heaters operating at one-half or less of rated voltage. Provide outside-air openings with insect and rodent screens and filters; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
h. Interior Space Conditioning: Air conditioned.

2.7 CIRCUIT BREAKERS

A. Drawout type, unfused, power operated, with electromechanical or electronic trip devices. Comply with IEEE C37.13, IEEE C37.13a, and UL 1066.

B. Coordinate "Ratings" Paragraph below with Drawings. See the Evaluations for ranges of preferred short-circuit current ratings.

C. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear. Comply with IEEE C37.16.

1. Circuit breakers shall have 30-cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85,000 A, whether or not equipped with instantaneous trip protection.

D. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.

2. Slow Closing Speed: Optional with operator for inspection and adjustment.

3. Stored-Energy Mechanism: Manually charged Electrically charged Electrically charged, and the operator's choice of manual charging.
   a. Operating Handle: One for each circuit breaker capable of manual operation.
   b. Electric Close Button: One for each electrically operated circuit breaker.

4. Provide an interlock to discharge the stored energy mechanism before the circuit breaker can be withdrawn from its compartment.

5. Operation counter.

E. Operator Display: Located on the face of the circuit breaker.

1. Electrical operation buttons to open and close the circuit breaker. Provide a clear lockable cover over the buttons.

2. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. An energized or hot condition shall be indicated by a red light. The de-energized, open, and safe condition shall be indicated by a green light.

3. Indicator to show the position of the circuit-breaker contacts, status of the closing springs, and circuit-breaker position in its compartment.

4. Provide a "charged-not OK to close" indicator when closing springs are charged but circuit breaker is not ready to close.

5. Retain "Computer Display" Subparagraph below to replace or augment data that are generated by the instrumentation inherent in the circuit breaker to provide the specified functionality.

6. Computer Display: One or more touchscreen computer displays, each with a dedicated CPU, to display data that are generated for transmission via the Ethernet connection. Display the following functions:
   a. Circuit-breaker status and circuit-breaker controls status.
   b. Onboard meters.
   c. User settings for overcurrent protection and undervoltage protection.
   d. .

F. Overcurrent Protective Tripping: Microprocessor-based, programmable, time-current shaping adjustments; complete with current transformers and sensors and the following features:

1. Programmable functions independent of each other in both action and adjustment.
   a. Long-time setting.
   b. Long-time-delay with selectable I2T or I4T curve shaping.
   c. Short-time setting.
   d. Short-time-delay with flat or selectable I2T curve shaping.
   e. Instantaneous trip.

2. Field-adjustable, time-current characteristics.

3. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.

4. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."

5. Pickup Points:
   a. Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-T operation.
   b. Five minimum, for instantaneous-trip functions.

G. Ground-Fault Protection:

1. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.

2. Retain one of two subparagraphs below.

3. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

4. Test Form: Provide each ground-fault relay with information sheets describing system-testing instructions, and with a test form; comply with UL 1558.

H. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.

I. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

J. Locate shunt-trip and associated controls on Drawings.

K. Shunt-Trip Devices.

L. Metering specified in first paragraph below is usually inherent with the circuit breaker and may be unsuitable for billing purposes.

M. Metering:

1. Accuracy: 0.5 1.0 percent of reading, complying with ANSI C12.20.

2. Values shall be rms average over a period of one second.
   a. Current: Each phase, neutral and three-phase average.
   b. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
   c. Active Power (kW): Each phase and three-phase total.
   d. Reactive Power (kVAr): Each phase and three-phase total.
   e. Apparent Power (kVA): Each phase and three-phase total.
   f. Power Factor: Each phase and three-phase total.
   g. Active Energy (kWh): Three-phase total.

N. Auxiliary Contacts:

1. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.

2. Spare auxiliary switches, at least two, unless otherwise indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

O. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

P. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

Q. "Mechanical Interlocking of Circuit Breakers" Paragraph below limits competition, because some manufacturers will not provide mechanical interlocks.

R. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

S. Key Interlocks: Arranged to prevent opening or closing of interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.

2.8 ARC-FLASH LIMITING FEEDER CIRCUIT BREAKERS

A. Feeder circuit breakers shall be without current-limiting fuses, listed as complying with UL 1066.

B. Short-circuit withstand current rating shall be 200 kA.

C. Equip the arc-flash limiting feeder circuit breakers with Arc-Flash Maintenance Setting switch for use as a temporary arc-flash incident energy-reduction device during maintenance activities on that feeder.

1. Provide a manual switch on the compartment door to switch the circuit-breaker short-time tripping characteristics to instantaneous with minimum pickup setting, to reduce the danger from potential arc-flash at downstream equipment.

2. Provide a lock feature for the switch so that it may be locked in either the off or on maintenance-mode position.

3. Provide a blue LED indicating light to indicate that the switch is in maintenance mode.

4. Provide dry relay contacts on each switch for annunciation of the switch position.

2.9 ZONE-SELECTIVE INTERLOCKING

A. Trip units for indicated circuit breakers shall include zone-interlocking capability for the short-time delay and ground-fault delay trip functions for system coordination and arc energy reduction. Zone-interlocking system shall restrain the tripping of an upstream circuit breaker and allow the circuit breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the preset time delay. Zone-interlock system shall be factory wired and tested for circuit breakers within the switchgear.

2.10 NETWORK PROTECTORS

A. Comply with IEEE 57.12.44 and IEEE C37.20.1. Switch shall comply with UL 1066.

1. Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Include mechanical interlocks to prevent racking in and racking out when protector is closed.

2. Locate the relay and control panel on a separate drawout module.

3. Protector Operator: Spring-close and or stored-energy mechanism, rated to close on a 25,000 40,000-rms symmetrical load.

4. Program the relay with factory-default values. Make provisions to field adjust these values using relay calibration procedures. Include an antipumping program to lock the protector open under abnormal conditions.

5. Include current-limiting fuses on network side of protector for protection against switchboard bus faults.

B. Controls shall be via a microprocessor-based, three-phase network relay, with the following features and functions:

1. Protector control shall use a positive and negative sequence-based algorithm for current and voltage.

2. 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.

3. Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors shall be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.

4. Trip protector if there is a flow of reverse magnetizing current to its associated transformer.

5. Relay parameters and watt or watt-VAr trip values shall be field adjustable.

6. Protector shall not open under any fault on network side of protector.

7. Include auxiliary contacts and control wiring for use with remote pilot devices that provide remote trip and lockout functions in low-voltage switchgear. Include two spare auxiliary contacts and an equal number of NO and NC types.

C. Communicate the following network relay parameters:

1. Current in each phase.

2. Phase-to-phase and phase-to-neutral voltages.

3. Three-phase watts, VArs, and VA.

4. Frequency.

5. Power factor.

6. Network relay set points.

2.11 SURGE SUPPRESSION

A. Surge Suppression: Factory installed as an integral part of low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:

1. Integral disconnect switch.

2. Retain first subparagraph below to disconnect the SPD when low-current, high-impedance faults occur.

3. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

4. Indicator light display for protection status.

5. Form-C contacts rated at 5-A 250-V ac, one NO and one NC, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

6. Surge counter.

B. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits." Include the following features and accessories:

1. Integral disconnect switch.

2. Retain first subparagraph below to disconnect the SPD when low-current, high-impedance faults occur.

3. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

4. Indicator light display for protection status.

5. Form-C contacts rated at 5-A 250-V ac, one NO and one NC, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

6. Surge counter.

2.12 CONTROL POWER SUPPLY, 120-V AC

A. Control Power Transformer: Supply 120-V control circuits through dry-type control power transformers, include secondary disconnect devices.

1. Place transformers larger than 3 kVA in separate compartments at the bottom of the vertical section, including the related primary and secondary fuses.

2. Retain first subparagraph below for electrically interlocked main and tie circuit breakers.

3. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
   a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
   b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

4. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

2.13 CONTROL POWER SUPPLY, 24-V DC

A. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.

B. Battery: Standard VRLA Premium VRLA Vented NiCd, batteries, with battery disconnect and overcurrent protective device.

C. Coordinate "Rack" and "Accessories" paragraphs below with Drawings.

D. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.

E. Accessories:

1. Thermometers with specific-gravity correction scales.

2. Hydrometer syringes.

3. Set of cell numerals.

F. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

1. DC ammeter.

2. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.

3. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.

4. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell, and equalizing charge at 2.33 V per cell.

5. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation shall be automatic until manually reset.

6. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. Automatic charger operation shall resume after loss of ac power supply for any interval.

7. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. Device shall regulate charging current but shall not disconnect charger from either battery or ac supply.

8. Charger's Audible Noise: Less than 26 dB.

2.14 INSTRUMENTATION AND CONTROL

A. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

B. Ethernet Connectivity:

1. Install a multipoint, RS-485 Modbus serial communications network within the switchgear to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications.

2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.

3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 10 Base-T 100 Base-T 100 Base-TX 100 Base FX LAN.

4. Server Configuration:
   a. Initial network parameters set using a standard web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
   b. Network server shall be factory programmed with embedded HTML-formatted web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard web browser.
   c. Password-protected login, with password administration accessible from the LAN using a standard web browser.
   d. Operating Software: Suitable for local access; firewall protected.

5. All serial communications devices within the equipment shall be addressed at the factory and tested.

C. Instrument Transformers: Comply with IEEE C57.13. Instrument transformers may not be used to power space conditioning equipment associated with outdoor switchgear, of for power to convenience receptacles and lighting.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 Accuracy class of 0.3 with burdens of W, X, and Y.

2. Coordinate "Current Transformers" Subparagraph below with Drawings.

3. Current Transformers: Burden and Accuracy class suitable for connected relays, meters, and instruments.

D. Analog Instruments: Rectangular, 115 mm square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.