SECTION 261326 - MEDIUM-VOLTAGE, METAL-CLAD SWITCHGEAR

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. SUMMARY
				1. Section Includes:

Switchgear enclosure.

Switchgear construction.

Surge arresters.

Instruments.

Protective relays.

Control power supply.

Battery system control power supply.

Control network.

Warning labels and signs.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. BIL: Basic Impulse Insulation Level.
				2. NETA ATS: InterNational Electrical Testing Association, Acceptance Testing Specification.
				3. UPS: Uninterruptable power supply.
				4. VRLA: Valve-regulated, recombinant, lead-calcium acid.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of product.

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

Time-current characteristic curves for overcurrent protective devices.

* + - * 1. Shop Drawings: For each medium-voltage, metal-clad switchgear.

Include a tabulation of installed devices with features and ratings.

Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components, features, and mimic bus diagram.

Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts[**and leveling channels**].

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

Locate accessory and spare equipment storage.

Include single-line diagram.

Include control power wiring diagrams.

Retain first subparagraph below if batteries are selected as control power for electrically operated switches or circuit breakers.

Include batteries, battery rack, equipment base, and room layout.

Include copy of nameplate.

Test results of enclosure corrosion resistant finish.

Ratings the switchgear assembly:

Voltage.

Continuous current.

Short-circuit current.

Lightning impulse full-wave withstand voltage.

Utility company's metering provisions with indication of approval by utility company.

Retain "Design Calculations" subparagraph below if products are required to withstand specific design loads and Architect either has delegated design responsibility to Contractor or wants to review structural data as another way to verify products' compliance with performance requirements.

Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.

Relay settings.

Interface data with monitoring or control network.

Wiring Diagrams: For each switchgear assembly include the following:

Power, signal, and control wiring.

Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.

Schematic control diagrams.

Diagrams showing connections of component devices and equipment.

Schematic diagrams showing connections to remote devices[**including connection details to the communications network**].

* + - * 1. Quality Control Submittals:

Transformer Certified Test Reports:

Preliminary Data: Submit certified report of the Company’s standard tests for the transformer. Test report format shall be NEMA “Transformer Test Report”.

Final Approval: After approval of preliminary data and after construction of transformer, make routine commercial ANSI/IEEE tests at the factory on the actual transformer and submit certified test report. Test report format shall be NEMA “Transformer Test Report”.

Company Field Advisor Data: Include:

Name, business address and telephone number of Company Field Advisor secured for the required services.

Certified statement from the Company listing the qualifications of the Company Field Advisor.

Services and each product for which authorization is given by the Company listed specifically for this project.

* + - * 1. Contract Closeout Submittals:

Test Report: System acceptance test report.

Certificate: Affidavit, signed by the Company Field Advisor and notarized, certifying that the system meets the Contract requirements and is operating properly.

Operation and Maintenance Data: Deliver two copies, covering the installed products to the Director’s Representative. Include name, address and telephone number of nearest fully equipped service organization.

Photographs:

After completion of the work take color photographs of the completed Work of this Section, as follows:

3 of the load center unit substation from different positions.

1 overall view of load center unit substation.

Nameplate(s)

Use a digital camera.  Use wide angle lens for overall view.  Use electronic flash capable of supplying sufficient light to evenly illuminate the overall subject.

Minimum digital requirements:

Format shall be .jpg or .tif

The resolution shall be 12 Megapixels or greater.

Submit photographs to electronic submittal website for approval and record.

Retain either "Outdoor Installations" or "Indoor Installations" subparagraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate subparagraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings:

Outdoor Installations:

Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.

Indoor Installations:

Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.

Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, cable trays, [**busways**] [**overhead hoists**] [**and**] [**seismic anchors**].

Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

Professional engineer qualifications pertain to structural design of seismic restraints.

* + - * 1. Qualification Data: For [**professional engineer**] [**and**] [**testing agency**].

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.

* + - * 1. Seismic Qualification Data: Certificates, for switchgear and control power, accessories, and components, from manufacturer.

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

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

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

Retain option in "Product Certificates" paragraph below if batteries are selected as control power for electrically operated switches or circuit breakers.

* + - * 1. Product Certificates: For switchgear [**and batteries**], signed by product manufacturer.
				2. Source quality-control reports.

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

* + - * 1. Field quality-control reports.
				2. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals.

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

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

* + - 1. MAINTENANCE MATERIAL SUBMITTALS

Extra materials may not be allowed for publicly funded projects.

* + - * 1. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Revise "Spare Fuses" subparagraph below to suit Project. Spare medium-voltage fuses are contained within primary switch.

Spare Fuses: [**Six**] <**Insert number**> of each type and rating of fuse and fusible device used, except for medium-voltage fuses[**and fuses associated with network protector**]. Include spares for the following:

Primary disconnect fuses.

Potential transformer fuses.

Control power fuses.

Fuses and fusible devices for fused circuit breakers.

Spare Indicating Lights: Six of each type installed.

Touchup Paint: [**Three**] <**Insert number**> half-pint containers of paint matching enclosure's exterior finish.

Primary Switch Contact Lubricant: [**One**] <**Insert number**> container(s).

* + - 1. QUALITY ASSURANCE

Retain "Testing Agency Qualifications" paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements in "Testing Agency Qualifications"

* + - * 1. Testing Agency Qualifications: Accredited by NETA.

Testing Agency's Field Supervisor: Certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in "Field Quality Control" Article.

* + - * 1. Equipment Qualifications For Products Other Than Those Specified:

At the time of submission provide written notice to the Director of the intent to propose an “or equal” for products other than those specified. Make the “or equal” submission in a timely manner to allow the Director sufficient time to review the proposed product, perform inspections and witness test demonstrations.

If products other than those specified are proposed for use furnish the name, address, and telephone numbers of at least 5 comparable installations that can prove the proposed products have performed satisfactorily for 3 years. Certify in writing that the Director’s Representative of the 5 comparable installations will allow inspection of their installation by the Director's Representative and the Company Field Advisor.

Make arrangements with the Director’s Representative of 2 installations (selected by the Director) for inspection of the installations by the Director's Representative. Also obtain the services of the Company Field Advisor for the proposed products to be present. Notify the Director a minimum of 3 weeks prior to the availability of the installations for the inspection, and provide at least one alternative date for each inspection.

Only references from the actual Director’s Representative or Director’s Representative (Security Supervisor, Maintenance Supervisor, etc.) will be accepted. References from dealers, system installers or others, who are not the actual Director’s Representative of the proposed products, are not acceptable.

Verify the accuracy of all references submitted prior to submission and certify in writing that the accuracy of the information has been confirmed.

The product manufacturer shall have test facilities available that can demonstrate that the proposed products meet the contract requirements.

Make arrangements with the test facility for the Director's Representative to witness test demonstrations. Also obtain the services of the Company Field Advisor for the proposed product to be present at the test facility. Notify the Director a minimum of 3 weeks prior to the availability of the test facility, and provide at least one alternative date for the testing.

Provide written certification from the manufacturer that the proposed products are compatible for use with all other equipment proposed for use for this system and meet all contract requirements.

* + - * 1. Company Field Advisor: Secure the services of a Company Field Advisor for a minimum of 8 working hours for the following:

Render advice regarding the load center unit substation installation, and final adjustment and testing of the load center unit substation devices.

Witness final system test and then certify with an affidavit that the load center unit substation is installed in accordance with the contract documents and is operating properly.

Train facility personnel on the operation and maintenance of the load center unit substation devices (minimum of two 1 hour sessions).

Explain available service programs to facility supervisory personnel for their consideration.

* + - * 1. Service Availability: A fully equipped service organization shall be available to service the completed Work.
			1. WARRANTY

When warranties are required, verify with Owner's counsel that special warranties stated in this article are not less than remedies available to Owner under prevailing local laws.

* + - * 1. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period.

Retain one of two subparagraphs below to specify typical industry battery-life warranty for type of battery specified in Part 2. Consult manufacturers' literature and revise, if applicable, to suit Project. See "DC Control System Batteries" Article in the Evaluations for detailed discussion.

Warranted Cycle Life for VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F:

For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than six discharge cycles.

For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.

For discharge rate not faster than 15 minutes, discharge duration not longer than 45 seconds, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 120 discharge cycles.

Warranted Cycle Life for Premium VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F:

For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 40 discharge cycles.

For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.

For discharge rate not faster than 15 minutes, discharge duration not longer than 1.5 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 750 discharge cycles.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. SYSTEM DESCRIPTION
				1. Manufactured Unit: [**Indoor**] [**and**] [**outdoor**], metal-clad switchgear, designed for application in [**solidly grounded neutral**] [**ungrounded**] [**impedance-grounded**] system.
				2. Comply with IEEE ANSI C37.20.2.
				3. The switchgear ratings shall comply with IEEE ANSI C37.04, and shall be the preferred ratings of IEEE ANSI C37.06.
				4. Switchgear 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. MANUFACTURERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=11099) Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

[Eaton](http://www.specagent.com/Lookup?uid=123457159913).

Powercon.

Approved equivalent.

* + - 1. PERFORMANCE REQUIREMENTS

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer.

* + - * 1. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**] <**Insert requirement**>.

Retain subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

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

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. If Project requires switchgear with a different Component Importance Factor, delete and add to schedule on the Drawings or to "Capacities and Characteristics" paragraph in "Switchgear Construction" Article.

Component Importance Factor: [**1.5**] [**1.0**].

See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in the subparagraphs below. See Editing Instruction No. 2 in the Evaluations for guidance.

Component Amplification Factor: [**2.5**] <**Insert number**>.

Component Response Modification Factor: [**6.0**] <**Insert number**>.

* + - * 1. Service Conditions:

Usual service conditions are ambient air temperature between minus 30 deg C and 40 deg C, and altitude not exceeding 3300 ft.; solar radiation is not significant.

Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE ANSI C37.20.2[**, except for the following:**][**.**]

List unusual service conditions in subparagraph(s) below. See "Service Conditions" Article in the Evaluations for listing of unusual service conditions that have to be considered by the switchgear manufacturer in order for the equipment to provide satisfactory service.

<**Insert unusual service condition**>.

* + - 1. SWITCHGEAR ENCLOSURE

Retain one of or both "Indoor Enclosure" and "Outdoor Enclosure" paragraphs below. Consider local experience and practice, especially for outdoor switchgear.

* + - * 1. Indoor Enclosure: Steel.

IEEE ANSI C37.20.2 Category A enclosures are intended to provide a degree of protection against contact with enclosed equipment in ground-level installations subject to deliberate acts by members of the unsupervised general public. Retain the optional text in the "Outdoor Enclosure" paragraph below when measures to exclude the general public from access to the switchgear are not included in the site design.

* + - * 1. Outdoor Enclosure: Weatherproof, galvanized steel, designed for installation outdoors. With full-height doors, with provisions for padlocking. With an integral structural-steel base frame with factory-applied asphaltic undercoating.[**The enclosure shall meet IEEE ANSI C37.20.2 Annex A, Category A enclosure requirements.**]

Each vertical section shall have the following features:

Structural design and anchorage adequate to resist loads imposed by [**125-mph**] <**Insert wind speed**> wind.

Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.

Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.

Weatherproof ground-fault circuit interrupter duplex receptacles.

Power for heaters and receptacles shall be provided [**by control power transformer**] [**as indicated**].

Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

* + - * 1. Switchgear Enclosures Finish:

Retain one of three subparagraphs below, depending on corrosion protection requirements. Retain first subparagraph for outdoor units and second for indoor units. Retain third for higher corrosion resistance for locations such as waste-water treatment plants and similar environments that are subject to salt spray.

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

Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

Factory-applied corrosion-resistant finish in manufacturer's standard color that withstands [**120**] [**480**] hours of exposure to the 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 1/16 inch from the test mark. The scribed test mark and test evaluation shall be conducted in accordance with ASTM D1654, with a rating of not less than 7 arrived at in accordance with 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.

* + - 1. SWITCHGEAR CONSTRUCTION
				1. Deadfront, metal-clad, drawout, switchgear assembly of vertical sections, each with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

Front and rear access switchgear.

Front and rear vertical section covers with full-length hinges. The front cover shall be a flanged door with latching hardware. The rear cover may be bolted.

See "Arc Resistance" Article in the Evaluations for guidance before retaining one of the options in subparagraph below.

Switchgear shall be arc resistant, complying with IEEE ANSI C37.20.7, [**Type 1A**] [**Type 2A**] [**Type 1C**] [**Type 2C**].

* + - * 1. Bus: [**Tin-plated**] [**Silver-plated**] copper.

Ground Bus: Sized to carry the rated short-time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.

Retain "Neutral Bus" subparagraph below and indicate on Drawings. Neutral bus is typically not needed in medium-voltage switchgear.

Neutral Bus: Rated [**600 A**] <**Insert value**>.

* + - * 1. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks[**, and an electrical racking motor and accessories for remote racking of the circuit breaker**].
				2. Auxiliary Vertical Sections and Compartments:

Utility metering compartment that complies with utility company requirements.

Director’s Representative's Metering:

Retain one of two subparagraphs below.

A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.

Hinged panel in switch or breaker section, for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.

* + - * 1. Circuit Breakers: Horizontally mounted, drawout, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

Electrically Operated:

Retain one of two subparagraphs below. When retaining the "external power" or a V dc option in subparagraphs below, indicate source on Drawings.

[**120 V ac**] [**230 V ac**] close, ac capacitor trip. Powered [**from external power source**] [**from a fused control transformer integral to the switchgear**].

[**48**] [**120**] [**240**] V dc close and trip. Powered from an external power source.

* + - * 1. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation.

One of each size handling device to remove the circuit breaker from metal-clad switchgear and to move the breaker about on the floor.

Test cabinet with accessories to connect to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when it is removed from the housing.

The default values listed in the "Capacities and Characteristics" paragraph below are for a typical 5 kV and a 15 kV system, taken from the preferred ratings listed in IEEE ANSI C37.06 for Class S1 circuit breakers. See "Preferred Ratings" Article in the Evaluations for discussion of capacities and characteristics. Include other ratings as warranted to meet Project requirements. Other requirements include maximum design voltages of 27 kV and 38 kV, ratings for Class S2 circuit breakers, capacitance current switching ratings, circuit breakers applied to gas-insulated substations, and other conditions listed in IEEE ANSI C37.06.

* + - * 1. Capacities and Characteristics:

Comply with IEEE ANSI C37.06.

Switchgear Assembly:

Rated Maximum Design Voltage and BIL (Dielectric Test): [**4.76 kV, 60 kV**] [**15 kV, 95 kV**] <**Insert value**>.

Rated Continuous Current: [**1200 A**] [**2000 A**] <**Insert value**>.

Rated Short-Circuit Current and Short-Time Current: [**40 kA rms**] <**Insert value**>.

<**Insert requirements**>.

Circuit Breakers:

Same capacities and characteristics as the switchgear assembly, and as follows:

Rated Continuous Current and Load Switching Current: [**1200 A**] [**2000 A**] <**Insert value**>.

According to IEEE ANSI C37.06, for 60 Hz, rated closing and latching current (kA, peak) of the circuit breaker is 2.6 times the rated short-circuit current. (If expressed in terms of kA, rms total current, the equivalent value is 1.55 times rated short-circuit current.)

Rated Closing and Latching Current: [**104 kA, peak**] <**Insert value**>.

Rated Interrupting Time: [**50 ms**] [**83 ms**].

<**Insert requirements**>.

* + - 1. SURGE ARRESTERS

Revise this article to specify station or intermediate-class arresters if Project conditions require. Coordinate ratings with Drawings. See Editing Instruction No. 1 in the Evaluations for discussion on applying surge arresters.

* + - * 1. Comply with IEEE ANSI C62.11, distribution class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.
			1. INSTRUMENTS
				1. Instrument Transformers: Comply with IEEE ANSI C57.13.

Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.

Coordinate "Current Transformers" subparagraph below with Drawings.

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

Retain "Metering" or "Multifunction Digital Meter and Monitor" paragraph.

* + - * 1. Metering: Install the following listed Director’s Representative's instruments, comply with requirements in Section 260913 "Electrical Power Monitoring and Control":

<**Insert requirements**>.

* + - * 1. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.

Switch-selectable digital display with the following features:

Phase Currents, Each Phase: Plus or minus 1 percent.

Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.

Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

Three-Phase Real Power: Plus or minus 2 percent.

Three-Phase Reactive Power: Plus or minus 2 percent.

Power Factor: Plus or minus 2 percent.

Frequency: Plus or minus 0.5 percent.

Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.

First subparagraph below specifies an optional feature.

Accumulated energy, in megawatt hours, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

Coordinate first subparagraph below with Section 260913 "Electrical Power Monitoring and Control" or with other remote monitoring system.

Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements in accordance with Section 260913 "Electrical Power Monitoring and Control."

Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

Delete "Analog Instruments" paragraph below if specifying multifunction digital-metering monitor.

* + - * 1. Analog Instruments: Rectangular, 4-1/2 inches square, 1 percent accuracy, semiflush mounting, with anti-parallax 250-degree scale and external zero adjustment.

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

Delete option in "Voltmeter Selector Switch" subparagraph below for three-wire systems.

Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase[**and phase-to-neutral**] voltages.

Ammeters: Cover an expanded scale range of bus rating plus 10 percent.

Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.

Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.

Revise electrical characteristics in "Watt-Hour Meters" subparagraph below to suit Project.

Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, [**15-minute**] <**Insert value**> indicating demand register, and provision for testing and adding pulse initiation.

Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with [**15-minute**] <**Insert value**> interval.

Operation: Counts and records a succession of pulses entering two channels.

Housing: Drawout, back-connected case arranged for semiflush mounting.

* + - 1. PROTECTIVE RELAYS

Retain this article when relays are not included with the circuit breakers articles. Coordinate relay functions and characteristics with the medium-voltage circuit breakers, the overcurrent protective device coordination study, and the arc-flash study. Delete if indicated on Drawings. Coordinate requirements for the studies in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."

* + - * 1. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE ANSI C37.90.
				2. Relay Mounting:

Each relay shall be mounted in a drawout case with a two-stage quick-release operation.

Removal of the relay from the case shall disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.

When the relay is inserted into the case, control power connections shall be made before the trip circuits are activated.

Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.

Coordinate first paragraph below with Section 260913 "Electrical Power Monitoring and Control" and with other remote monitoring systems.

* + - * 1. Equip each relay system with a communications module to transmit the following data in accordance with Section 260913 "Electrical Power Monitoring and Control."

Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.

Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

* + - * 1. Overcurrent and Ground-Fault Protective Relays:

IEEE ANSI C37.2 device functions [**51/50 and 51/50N**] <**Insert value**>.

Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.

Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.

Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.

Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and shall be deactivated after approximately eight cycles.

Contacts:

Two Form-A contacts.

Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

One contact assigned function 51 phase and function 51 ground, and the other contact assigned function 50 phase and function 50 ground.

One contact assigned function 51/50 phase, and the other contact assigned function 51/50 ground.

Alphameric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

Individual phase currents.

Ground current.

Cause of trip.

Magnitude and phase of current-causing trip.

Phase or ground indication.

Peak current demand for each phase and ground since last reset.

Current-transformer primary rating.

Programmed phase and ground set points.

Relay alarm and trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm shall be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay shall be de-energized, providing a fail-safe protection off alarm.

Insert other relay types in paragraph below when adding other relays to operate circuit breakers in the switchgear. The 51/50 overcurrent relay described in "Overcurrent and Ground-Fault Protective Relays" paragraph above is typical of microprocessor-based protective relays. Show each relay system on the one-line diagram.

Specify setting and testing of microprocessor-based relays for specific applications in "Field Quality Control" Article.

* + - * 1. <**Insert other relay types**>.

Retain "Control Power Supply" or "Battery System Control Power Supply" Article for control power of the circuit breakers. The first article is for ac control power, and the second is for battery-powered dc supply.

* + - 1. CONTROL POWER SUPPLY
				1. Description:

Retain first two subparagraphs or third subparagraph below.

Control power transformer shall supply 120 V ac control circuits through secondary disconnect and overcurrent protective devices.

Dry-type transformer, in separate compartment, with primary and secondary fuses to provide current-limiting and overload protection.

If retaining subparagraph below, indicate ratings and capacities as specified in the referenced Section.

Uninterruptible ac power supply complying with requirements of Section 263353 "Static Uninterruptible Power Supply."

* + - 1. BATTERY SYSTEM CONTROL POWER SUPPLY
				1. Dedicated [**48 V dc**] [**120 V dc**] [**240 V dc**] battery system.

Coordinate "System Requirements" paragraph below with Drawings or revise to specify number of cells and required minimum ampere-hour capacity of battery. The difference between standard VRLA and premium VRLA batteries is the length of the pro rata warranty period. See "Warranty" Article.

* + - * 1. 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 to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.
				2. Battery:

Coordinate first two subparagraphs below with Drawings. See Editing Instruction No. 4 in the Evaluations for guidance on battery selection.

[**Standard VRLA**] [**Premium VRLA**] <**Insert type**> batteries, with system disconnect and overcurrent protective device.

Rack: [**Two**] <**Insert number**>-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.**]

Accessories:

Set of cell numerals.

Monitoring system.

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.

DC ammeter.

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

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.

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.

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

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.

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

Charger's Audible Noise: Less than 26 dB.

* + - * 1. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
				2. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.

Conductors: Sized in accordance with NFPA 70 for duty required.

* + - 1. Compartment Enumeration:

The following cubicle enumerations are general examples for outdoor type construction. Refer to manufacturers’ catalogs for equipment which can be specifically accommodated by each cubicle.

1. Compartment No. 1:

Metal-enclosed unit.

1. 3 phase bus, \_\_\_\_\_\_\_\_ amps.
2. Fusible air interrupter switch, single throw, manually operated, 3 pole, 600 amps.

Motor operated switches are available.

1. 3 - \_\_\_\_\_\_\_\_KV fuses.
2. 3 - Lightning arresters.
3. 1 - Space heater of wattage as required.
4. Provisions for terminating cables. Necessary small wiring, terminal blocks, ground bus, etc.
5. Key Interlocking between switch mechanisms supplied by 2 primary feeders, so that only one switch can be in the closed position.
6. Compartment No. 2 (Metering):

Use cubicle no. 2 and modify to suit only where project requirements warrant use of primary metering instead of secondary metering.

1 - Metal-enclosed unit.

1. 1 - 3 phase bus, \_\_\_\_\_\_\_\_ amps.
2. 3 - Potential transformers with current limiting fuses.
3. 3 - Current transformers \_\_\_\_\_\_\_\_/5 ratio.
4. 1 - Ammeter, indicating type 0 to \_\_\_\_\_\_\_\_ ampere range.
5. 1 - Ammeter transfer switch.
6. 1 - Voltmeter, indicating type 0 to \_\_\_\_\_\_\_\_KV range.
7. 1 - Voltmeter transfer switch.
8. 1 - Indicating KW meter 0 to \_\_\_\_\_\_\_\_KW with demand register.
9. 1 - Space heater of wattage as required.
10. Necessary small wiring, terminal blocks, ground bus, etc.
11. Compartment No. 3 (Auxiliary):

1 - Metal-enclosed unit

1 - 3 phase bus, \_\_\_\_\_\_\_\_ amps.

1 - Control power transformer with current limiting fuses.

1 - AC panel of capacity to serve load requirements with main circuit breaker and required number of branch circuit breakers, plus 4 spare single pole branch circuit breakers.

1 - Space heater of wattage as required.

* + - 1. CONTROL NETWORK

Retain "Compliance with ASHRAE 135" paragraph below for interfacing with direct digital control system or similar monitoring or control network. Revise as required for other networks protocols and to coordinate with other sections that connect to the control network.

See Editing Instruction No. 3 in the Evaluations for guidance on communication network options.

* + - * 1. Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications and shall be able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.
			1. WARNING LABELS AND SIGNS

The reference to Section 260553 "Identification for Electrical Systems," and products specified therein, includes the requirement to comply with NFPA 70 and 29 CFR 1910.145.

* + - * 1. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

Warning signs shall be baked enamel signs.

Equipment Identification Labels: [**Laminated acrylic or melamine plastic signs**] [**Stenciled legend, minimum 4 inches (100 mm) high**].

* + - 1. SOURCE QUALITY CONTROL
				1. Perform production tests on each circuit breaker housing for this Project, complying with IEEE ANSI C37.09.

Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.

Conduct an alignment test with master circuit breaker to verify all interfaces.

Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.

Perform the control wiring dielectric test at 1500 V for one minute.

Perform the dielectric test on primary and secondary circuits.

* + - * 1. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE ANSI C37.09.

Perform mechanical operation tests to ensure proper functioning of the switch.

Conduct an alignment test with master cell to verify all interfaces and interchangeability.

Verify the contact gap. Perform terminal-to-terminal resistance test.

Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.

Perform the control wiring dielectric test at 1500 V for one minute.

Set the contact gap.

* + - * 1. Director’s Representative will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
1. EXECUTION
	* + 1. EXAMINATION
				1. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.

Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.

Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.

Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and shop drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.

Unload switchgear, observing packing label warnings and handling instructions.

Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

* + - * 1. Handling:

Handle switchgear in accordance with manufacturer's recommendations, avoid damage to the enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.

Protect switchgear compartments against the entrance of dust, rain, and snow.

Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.

Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.

Do not damage structure when handling switchgear.

* + - * 1. Storage:

Store switchgear in a location that is clean and protected from weather. Protect switchgear from dirt, water, contamination, and physical damage. Do not store switchgear in the presence of corrosive or explosive gases.

Store switchgear with compartment doors closed.

Regularly inspect switchgear while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions.

* + - * 1. Examine roughing-in of conduits and grounding systems to verify the following:

Wiring entries comply with layout requirements.

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

* + - * 1. Pre-Installation Checks:

Verify removal of any shipping bracing after placement.

Adjust 5-ohm value in first paragraph below to suit Project conditions.

* + - * 1. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be [**5 ohms**] <**Insert value**> ohms at switchgear location.
				2. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. INSTALLATION OF SWITCHGEAR
				1. Comply with the provisions of IEEE ANSI C37.20.2 subclause titled "Guide for Handling, Storage, and Installation."
				2. Equipment Mounting:

Retain first subparagraph below to require equipment to be installed on cast-in-place concrete equipment bases.

Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

Retain one of two subparagraphs below. Retain first for projects in seismic areas; retain second for projects not in seismic areas. Indicate vibration isolation and seismic-control device type and minimum deflection in supported equipment schedule on Drawings.

Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

Comply with requirements for vibration isolation devices specified in Section 260529 "Hangers and Supports for Electrical Systems."

* + - * 1. Switchgear shall be installed level and plumb. Switchgear shall tilt less than 1.5 degrees while energized.
				2. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's written instructions and NFPA 70.
				3. Comply with NECA 1.
				4. Comply with NECA 430.
			1. CONNECTIONS
				1. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
				2. Grounding Connections at Interior Locations:

Install bare copper cable not smaller than No. 4/0 AWG for grounding to grounding electrodes.

Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.

Keep leads as short as practicable with no kinks or sharp bends.

Make joints in grounding conductors and loops by exothermic weld or compression connector.

* + - * 1. Grounding at Exterior Locations:

Install tinned bare copper cable not smaller than No. 4/0 AWG, for counterpoise buried not less than 30 inches below grade interconnecting the grounding electrodes.

Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown.

Keep lead lengths as short as practicable with no kinks or sharp bends.

Fence and equipment connections shall not be smaller than No. 4 AWG.

Ground fence at each gate post and corner post and at intervals not exceeding 10 ft..

Bond each gate section to the fence post using 1/8 by 1 inch [**tinned**]flexible braided copper strap and clamps.

Make joints in grounding conductors and loops by exothermic weld or compression connector.

* + - * 1. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.
				2. Complete switchgear grounding and lightning arrester connections prior to making any other electrical connections.
				3. Terminate medium-voltage cables in accordance with Section 260513 "Medium-Voltage Cables."
			1. SIGNS AND LABELS
				1. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
				2. Install warning signs as required to comply with 29 CFR 1910.269.
			2. FIELD QUALITY CONTROL

Retain first paragraph below to require that field quality-control tests be witnessed. Local ordinance or custom may require that authorities having jurisdiction witness the testing.

* + - * 1. Field tests must be witnessed by [**Architect**] [**Tenant**] [**authorities having jurisdiction**] <**Insert names or titles of witnesses**>.
				2. Administrant for Tests and Inspections:

Retain one of four subparagraphs below to specify who administers and performs tests and inspections. Coordinate testing responsibilities with Owner or Tenant before selecting first subparagraph.

[**Director’s Representative**] [**Tenant**] will engage qualified testing agency to administer and perform tests and inspections.

Engage qualified testing agency to administer and perform tests and inspections.

Engage Company Service Advisor to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

* + - * 1. Administer and perform tests and inspections[**with assistance of** Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. General Field Testing Requirements:

The NFPA 70B reference in first subparagraph below contains requirements for qualifications of test operators and test equipment.

Comply with the provisions of NFPA 70B, "Testing and Test Methods."

After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.

Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

* + - * 1. Medium-Voltage Switchgear Assembly Field Tests:

Visual and Mechanical Inspection:

Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study[**, as well as to the circuit breaker's address in the control network**].

Verify that current and voltage transformer ratios correspond to Drawings.

Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

Confirm correct operation and sequencing of electrical and mechanical interlock systems.

Attempt closure on locked-open devices. Attempt to open locked-closed devices.

Make key exchange with devices operated in off-normal positions.

Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

Inspect insulators for evidence of physical damage or contaminated surfaces.

Verify correct barrier and shutter installation and operation.

Exercise active components.

Inspect mechanical indicating devices for correct operation.

Verify that filters are in place and vents are clear.

Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.

Inspect control power transformers.

Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

Verify that primary and secondary fuse or circuit breaker ratings match drawings.

Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

Electrical Tests:

Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.

Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V dc for 300-volt rated cable and 1000 V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

Minimum insulation-resistance values of control wiring shall not be less than two megohms.

Control Power Transformers:

Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.

Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.

Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

Voltage Transformers:

Perform secondary wiring integrity test. Verify correct potential at all devices.

Verify secondary voltages by energizing the primary winding with system voltage.

Perform current-injection tests on the entire current circuit in each section of switchgear.

Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

NETA considers the current test by primary injection in subparagraph below to be optional.

Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

Perform system function tests in accordance with "System Function Tests" Article.

Verify operation of space heaters.

Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

* + - * 1. Medium-Voltage Vacuum Circuit Breaker Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, grounding, and required clearances.

Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.

Verify the unit is clean.

Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.

Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism shall be in accordance with manufacturer's published data.

Verify cell fit and element alignment.

Verify racking mechanism operation.

Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

Retain one of first two subparagraphs below, or both. The verification of lubrication and time-travel tests are normally considered optional field tests.

Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

Perform time-travel analysis. Travel and velocity values shall be in accordance with manufacturer's published data.

Record as-found and as-left operation counter reading. Operation counter shall advance one digit per close-open cycle.

Electrical Tests:

Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.

Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils shall comply with manufacturer's published data. In the absence of the manufacturer's published data, comply with NETA ATS, Table 100.20.

Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features shall operate in accordance with manufacturer's published data.

Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.

Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values shall comply with manufacturer's published data.

Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.

Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

Verify operation of heaters.

* + - * 1. Instrument Transformer Field Tests:

Visual and Mechanical Inspection:

Verify that equipment nameplate data complies with Contract Documents.

Inspect physical and mechanical condition.

Verify correct connection of transformers with system requirements.

Verify that adequate clearances exist between primary and secondary circuit wiring.

Verify the unit is clean.

Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

Verify that all required grounding and shorting connections provide contact.

Verify correct operation of transformer withdrawal mechanism and grounding operation.

Verify correct primary and secondary fuse sizes for voltage transformers.

Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

Electrical Tests of Current Transformers:

Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's written recommendations or NETA ATS, Table 100.5.

Perform a polarity test of each current transformer in accordance with IEEE ANSI C57.13.1. Polarity results shall agree with transformer markings.

IEEE ANSI C57.13, referred to in the subparagraph below, requires ratio errors for applications other than revenue metering to be plus or minus 1.2 percent. This may be too stringent for relaying, load control, and similar applications.

Perform a ratio-verification test using the voltage or current method in accordance with IEEE ANSI C57.13.1. Ratio errors shall be in accordance with IEEE ANSI C57.13.

Perform an excitation test on transformers used for relaying applications in accordance with IEEE ANSI C57.13.1. Excitation results shall match the curve supplied by the manufacturer or be in accordance with IEEE ANSI C57.13.1.

Measure current circuit burdens at transformer terminals in accordance with IEEE ANSI C57.13.1. Measured burdens shall be compared with and shall match instrument transformer ratings.

Retain subparagraph below when applicable.

Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with Table 100.5.

Retain subparagraph below when applicable.

Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with Table 100.9.

Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.

Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

Electrical Tests of Voltage Transformers:

Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages shall be applied for one minute in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.

Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. Polarity results shall agree with transformer markings.

IEEE ANSI C57.13, referred to in the subparagraph below, requires ratio errors for applications other than revenue metering to be plus or minus 1.2 percent. This may be too stringent for relaying, load control, and similar applications.

Perform a turns-ratio test on all tap positions. Ratio errors shall be in accordance with IEEE ANSI C57.13.

Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared with and shall match instrument transformer ratings.

NETA considers the dielectric withstand test on the primary windings in subparagraph below to be optional.

Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall be in accordance with Table 100.9. The test voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary windings are considered to have passed the test.

Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.

Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. Test results shall indicate that the circuits are grounded at only one point.

* + - * 1. Ground Resistance Test:

Visual and Mechanical Inspection:

Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."

Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.

Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

Inspect anchorage.

Electrical Tests:

Select the resistance value options based on guidance offered by IEEE Std 142: "The resistance between the main grounding electrode and ground shall be no more than five ohms for large commercial or industrial systems and 1.0 ohm or less for generating or transmission station grounds."

Perform fall-of-potential or alternative test in accordance with IEEE Std 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground shall be no more than [**5 ohms**] [**maximum resistance value specified in "Examination" Article**].

Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.

Inspect physical and mechanical condition.

Inspect bolted electrical connections for high resistance using a low resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

* + - * 1. Metering Devices Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.

Verify the unit is clean.

Verify freedom of movement, end play, and alignment of rotating disk(s).

Electrical Tests:

Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

Verify accuracy of meters at all cardinal points. Meter accuracy shall be in accordance with manufacturer's published data.

Calibrate meters in accordance with manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.

Verify all instrument multipliers. Instrument multipliers shall be in accordance with system design specifications.

Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

* + - * 1. Medium-Voltage Surge Arrester Field Tests:

Visual and Mechanical Inspection:

Verify that equipment nameplate data complies with Contract Documents.

Inspect physical and mechanical condition.

Inspect anchorage, alignment, grounding, and clearances.

Verify the arresters are clean.

Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

Electrical Test:

Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.

Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

Test grounding connections. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

* + - * 1. Microprocessor-Based Protective Relay Field Tests:

Visual and Mechanical Inspection:

Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.

Verify operation of light-emitting diodes, display, and targets.

Record passwords for each access level.

Clean the front panel and remove foreign material from the case.

Check tightness of connections.

Verify that the frame is grounded in accordance with manufacturer's instructions.

Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."

Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

Electrical Tests:

Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.

Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.

Functional Operation: Check functional operation of each element used in the protection scheme as follows:

Retain relays specified in Part 2.

Timing Relay:

Determine time delay.

Verify operation of instantaneous contacts.

Volts/Hertz Relay:

Determine pickup frequency at rated voltage.

Determine pickup frequency at a second voltage level.

Determine time delay.

Sync Check Relay:

Determine closing zone at rated voltage.

Determine maximum voltage differential that permits closing at zero degrees.

Determine live line, live bus, dead line, and dead bus set points.

Determine time delay.

Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

Undervoltage Relay:

Determine dropout voltage.

Determine time delay.

Determine time delay at a second point on the timing curve for inverse time relays.

Directional Power Relay:

Determine minimum pickup at maximum torque angle.

Determine closing zone.

Determine maximum torque angle.

Determine time delay.

Verify time delay at a second point on the timing curve for inverse time relays.

The plot in first subparagraph below is normally considered to be an optional field test.

Plot the operating characteristic.

Current Balance Relay:

Determine pickup of each unit.

Determine percent slope.

Determine time delay.

Negative Sequence Current Relay:

Determine negative sequence alarm level.

Determine negative sequence minimum trip level.

Determine maximum time delay.

Verify two points on the I-two-squared-t curve.

Phase Sequence or Phase Balance Voltage Relay:

Determine positive sequence voltage to close the NO contact.

Determine positive sequence voltage to open the NC contact (undervoltage trip).

Verify negative sequence trip.

Determine time delay to close the NO contact with sudden application of 120 percent of pickup.

Determine time delay to close the NC contact upon removal of voltage when previously set to rated system voltage.

Instantaneous Overcurrent Relay:

Determine pickup.

Determine dropout.

The time delay determination in first subparagraph below is normally considered an optional field test.

Determine time delay.

Time Overcurrent:

Determine minimum pickup.

Determine time delay at two points on the time current curve.

Ground Detector Relay:

Determine maximum impedance to ground causing relay pickup.

Directional Overcurrent Relay:

Determine directional unit minimum pickup at maximum torque angle.

Determine closing zone.

The maximum torque angle determination and the plot in the first two subparagraphs below are normally considered optional field tests.

Determine maximum torque angle.

Plot operating characteristics.

Determine overcurrent unit pickup.

Determine overcurrent unit time delay at two points on the time current curve.

Control Verification:

Functional Tests:

Check operation of all active digital inputs.

Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.

Check internal logic functions used in protection scheme.

Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

* + - * 1. DC System VRLA Batteries Field Test:

Visual and Mechanical Inspection:

Verify that batteries are adequately located.

Verify that battery area ventilation system is operable.

Verify existence of suitable eyewash equipment.

Verify equipment nameplate data complies with Contract Documents.

Inspect physical and mechanical condition.

Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.

Verify the units are clean.

Inspect spill containment installation.

Verify application of an oxide inhibitor on battery terminal connections.

Electrical Tests:

Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.

Verify charger functions and that alarms comply with system manufacturer's recommendations.

Measure negative post temperature. Negative post temperature shall comply with manufacturer's published data or IEEE Std 1188.

Measure charger float and equalizing voltage levels. Charger float and equalizing voltage levels shall be in accordance with the battery manufacturer's published data.

Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation. Monoblock/cell voltages shall be in accordance with manufacturer's published data.

Measure intercell connection resistances.

Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical monoblocks/cells in a fully charged state.

Perform a load test in accordance with manufacturer's published data or IEEE Std 1188. Replace units that fail to pass the test.

Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive to ground shall be equal in magnitude to the voltage measured from negative to ground.

* + - * 1. DC System Vented NiCd Batteries Field Test:

Visual and Mechanical Inspection:

Verify that batteries are adequately located.

Verify that battery area ventilation system is operable.

Verify existence of suitable eyewash equipment.

Verify equipment nameplate data complies with Contract Documents.

Inspect physical and mechanical condition.

Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.

Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.

Verify the units are clean.

Inspect spill containment installation.

Verify application of an oxide inhibitor on battery terminal connections.

Electrical Tests:

Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.

Verify charger functions and that alarms comply with system manufacturer's recommendations.

Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages shall be within 0.05 volt of each other or in accordance with manufacturer's published data.

Measure intercell connection resistances.

Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.

Perform a load test in accordance with manufacturer's published data or IEEE Std 1106. Replace units that fail to pass the test.

Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive-to-ground shall be equal in magnitude to the voltage measured from negative to ground.

* + - * 1. Nonconforming Work:

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

Remove and replace defective units and retest.

* + - * 1. Prepare test and inspection reports. Record as-left set points of adjustable devices.
			1. SYSTEM FUNCTION TESTS
				1. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.

Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.

Verify the correct operation of sensing devices, alarms, and indicating devices.

* + - 1. FOLLOW-UP SERVICE
				1. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, if requested by Director’s Representative, perform the following voltage monitoring:

During a period of normal load cycles as evaluated by Director’s Representative, perform seven days of three-phase voltage recording at the outgoing section of each switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.

Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

Adjust switchgear taps.

Prepare written request for voltage adjustment by electric utility.

Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.

Report:

Prepare a written report covering monitoring performed and corrective action taken.

* + - * 1. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove covers prior to the inspection.

After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.

Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C.

Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and lists the results as follows:

Description of equipment to be tested.

Discrepancies.

Temperature difference between the area of concern and the reference area.

Probable cause of temperature difference.

Areas inspected. Identify inaccessible and unobservable areas and equipment.

Identify load conditions at time of inspection.

Provide photographs and thermograms of the deficient area.

Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Director’s Representative's operations permit. Retest until deficiencies are corrected.

* + - 1. DEMONSTRATION
				1. [**Engage a Company Service Advisor to train**] [**Train**] Director’s Representative's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261326