SECTION 261116.11 - SECONDARY UNIT SUBSTATIONS WITH SWITCHGEAR SECONDARY

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. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section includes secondary unit substations, each consisting of medium-voltage primary incoming section, transformer section, and low-voltage secondary switchgear section, with the following features:

[**Indoor enclosure**] [**Outdoor enclosure**] [**Indoor and outdoor enclosures**].

Medium-voltage, [**metal-clad**] [**metal-enclosed**] switchgear section.

[**Liquid-filled**] [**Dry-type**] transformer.

* + - 1. DEFINITIONS

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

* + - * 1. BIL: Basic insulation level.
				2. MCC: Motor-control center.
				3. MVA: Megavolt ampere.
				4. NETA ATS: Acceptance testing specification.
				5. NiCd: Nickel cadmium.
				6. PCB: Polychlorinated biphenyl.
				7. RTD: Resistance temperature device.
				8. SCR: Silicon-controlled rectifier.
				9. SPD: Surge protective device.
				10. VRLA: Valve-regulated lead 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.

* + - * 1. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Wiring Diagrams: Power, signal, and control wiring.

Dimensioned plans and elevations showing major components and features.

Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

One-line diagram.

List of materials.

Nameplate legends.

The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.

Short-time and short-circuit current ratings of secondary unit substations and components.

Ratings of individual protective devices.

Mimic-bus diagram.

Curves below are required to coordinate devices upstream and downstream from secondary unit substation.

* + - * 1. Time-Current Characteristic Curves: For overcurrent protective devices.
				2. Primary Fuses: Submit recommendations and size calculations.

Retain subparagraph below to require provisions for utility company metering.

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

* + - * 1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.

Retain "Coordination Drawings" Paragraph 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 paragraph 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 for Outdoor Installations:

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

* + - * 1. Coordination Drawings for Indoor Installations:

Location plan, showing heavy equipment or truck access paths for maintenance and replacement.

Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.

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

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

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

* + - * 1. Qualification Data: For testing agency.

Retain "Seismic Qualification Certificates" 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 Certificates: For transformer assembly, 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.

* + - * 1. Product Certificates: For secondary unit substations, signed by product manufacturer.
				2. Factory test reports.
				3. Field quality-control reports.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.
			2. MAINTENANCE MATERIAL SUBMITTALS

Extra materials may not be allowed for publicly funded projects.

* + - * 1. Furnish extra materials 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.

Fuses for secondary fusible devices.

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).

[**One**] <**Insert number**> set(s) of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure-relief device.

* + - 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.

* + - * 1. Testing Agency Qualifications: Member company of NETA or an NRTL.

Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

* + - * 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. DELIVERY, STORAGE, AND HANDLING

Delete first paragraph below if no known obstacles to movement of normal shipping, lengths of secondary unit substations, and substation sections. Coordinate with Drawings.

* + - * 1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
				2. Coordinate delivery of secondary unit substations to allow movement into designated space.
				3. Store secondary unit substation components[**protected from weather and**] so condensation does not form on or in units. Provide temporary heating according to manufacturer's written instructions.
				4. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.
			1. FIELD CONDITIONS
				1. Service Conditions: The unit substation shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.121, except for the following:

Retain and modify conditions below, and specify features required to provide satisfactory service.

Significant solar radiation principles referred to in first subparagraph below are stated in IEEE C37.24.

Exposure to significant solar radiation.

Altitudes above 3300 feet.

Exposure to fumes, vapors, or dust.

Exposure to explosive environments.

Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.

Exposure to seismic shock or to abnormal vibration, shock, or tilting.

In first subparagraph below: Usual temperatures are down to minus 30 deg C, except minus 20 deg C for liquid-immersed transformers, and up to 40 deg C when average ambient air temperature in any 24-hour period is not more than 30 deg C.

Exposure to excessively high or low temperatures.

Unusual transportation or storage conditions.

Unusual grounding resistance conditions.

Unusual space limitations.

* + - 1. WARRANTY

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

* + - * 1. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of the dc system battery equipment that fail(s) in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

Warranty Period: Include the following warranty periods, from date of Substantial Completion:

DC System Equipment (excluding Batteries): [**One**] [**Two**] <**Insert number**> year(s).

Retain one of three subparagraphs below to match battery types retained in this Section. Verify, with manufacturers, availability of warranties.

Standard VRLA Batteries:

Full Warranty: [**One**] <**Insert number**> year(s).

Pro Rata: [**Nine**] <**Insert number**> years.

Premium VRLA Batteries:

Full Warranty: [**One**] <**Insert number**> year(s).

Pro Rata: [**19**] <**Insert number**> years.

Vented NiCd Batteries:

Full Warranty: [**Five**] <**Insert number**> years.

Pro Rata: [**15**] <**Insert number**> years.

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

ABB (Power Grids Division).

Eaton.

Schneider Electric USA (Square D).

Or equal.

* + - 1. SYSTEM DESCRIPTION
				1. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers, fusible switches, and metering components.

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.

Comply with IEEE C2.

Comply with IEEE C37.121.

Comply with NFPA 70.

* + - 1. PERFORMANCE REQUIREMENTS

Retain "Seismic Performance" Paragraph below with "Seismic Qualification Certificates" 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 secondary unit substations shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

Retain first 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 secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified [**and the secondary unit substation 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.

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 "Component Amplification Factor" and "Component Response Modification Factor" subparagraphs below. See Editing Instruction No. 9 in the Evaluations for guidance.

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

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

* + - 1. MANUFACTURED UNITS

The second option in first two paragraphs below is not applicable when "Secondary Distribution Section Network Protectors" or "Secondary Distribution Section Terminal Compartment" articles are retained.

* + - * 1. Indoor Unit Arrangement: [**Single assembly**] [**Separate secondary distribution equipment connected with busway**].
				2. Outdoor Unit Arrangement: [**Single assembly**] [**Separate secondary distribution equipment connected with busway**].

Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.

Aisle-less Construction: Full-height doors in front of basic weatherproof equipment.

* + - * 1. Connections between the primary device and transformer shall be [**cable**] [**bus**], and between the transformer and secondary shall be flexible bus braid unless noted otherwise.

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.
				2. Outdoor Enclosure: [**Weatherproof, aisle-less construction**] [**Weatherproof, sheltered-aisle construction, with interior-lighted walk-in aisle**] for outdoor service. Galvanized-steel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.

Enclosure: [**Flat**] [**Downward, rearward sloping**] roof; [**bolt-on rear covers**] [**rear hinged doors**] for each section, with provisions for padlocking.

Each compartment 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**] [**manual switching of branch-circuit protective device**].

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

Retain first three subparagraphs below unless weatherproof internal-aisle construction is retained.

Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle.

Weatherproof ground-fault circuit interrupter (GFCI) duplex receptacle.

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

Retain first subparagraph below for weatherproof internal-aisle construction.

Weatherproof internal-aisle construction shall have the following features:

Common internal aisle of sufficient width to permit protective device withdrawal, disassembly, and servicing in aisle.

Doors: Personnel door at each end of aisle, minimum width of [**30 inches**] <**Insert dimension**>; opening outwards; with panic hardware and provisions for [**padlocking**] [**cylinder lock**].

Aisle space heaters operating at one-half or less of rated voltage and thermostatically controlled.

Vapor-proof fluorescent aisle lights with low-temperature ballasts and controlled by wall switch at each entrance.

Emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.

GFCI duplex receptacles, a minimum of two, located in aisle.

In first two subparagraphs below, optional interior temperatures are based on minimum and maximum ambient temperatures considered reasonable at which derating of fuses and circuit breakers might be considered, and at which electronic devices might malfunction. Consult the climatic design information in the ASHRAE Handbook - Fundamentals for recommended maximum and minimum outside design temperatures for locations in which MCCs will be installed.

Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of [**10 deg F**] <**Insert temperature**> with outside design temperature of [**minus 20 deg F**] <**Insert temperature**>.

Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of [**85 deg F**] <**Insert temperature**> with outside design temperature of [**104 deg F**] <**Insert temperature**>.

Ventilating openings[**complete with replaceable fiberglass air filters**].

Thermostat: Single stage; wired to control heat and exhaust fan.

* + - * 1. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

Retain one of three "Unit Substation Enclosures Finish" paragraphs below, depending on the corrosion protection requirements. Retain first paragraph for outdoor units and second paragraph for indoor units. Retain third for higher corrosion resistance for locations such as waste-water treatment plants and similar environments where salt spray exists.

* + - * 1. Unit Substation Enclosures Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.
				2. Unit Substation Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.
				3. Unit Substation Enclosures Finish: 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 according to ASTM D1654, with a rating of not less than 7 arrived at according to 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. MEDIUM-VOLTAGE TERMINAL COMPARTMENT SECTION
				1. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.
				2. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.
				3. System Voltage: [**4.16 kV nominal; 4.76 kV maximum**] [**7.2 kV nominal; 15 kV maximum**] [**13.8 kV nominal; 15 kV maximum**] [**34.5 kV nominal; 38 kV maximum**] <**Insert other voltage**>.

Revise "Surge Arresters" Paragraph below to specify station or intermediate-class arresters if Project conditions require. Coordinate ratings with Drawings. See Editing Instruction No. 2 in the Evaluations for discussion on applying surge arresters.

* + - * 1. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

Retain one of next three medium-voltage section articles. If more than one type of secondary unit substation is required, indicate location on Drawings.

Delete all three medium-voltage section articles for overhead wire connection to the transformer section.

* + - 1. MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR SECTION
				1. Metal-clad, circuit-breaker switchgear, complying with IEEE C37.20.2 and NEMA SG 4 and tested for compliance according to NEMA C 37.55.

Retain "Arc Resistant" Subparagraph below to require compliance with IEEE C37.20.7. See Editing Instruction No. 3 in the Evaluations for guidance before retaining arc-resistant option in subparagraph below.

Arc Resistant: Comply with IEEE C37.20.7, [**Type 1**] [**Type 2**] [**Type 1C**] [**Type 2C**].

* + - * 1. Ratings shall comply with IEEE C37.04, suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

Retain three subparagraphs below unless ratings are shown on Drawings.

System Voltage: [**4.16 kV nominal; 4.76 kV maximum**] [**7.2 kV nominal; 15 kV maximum**] [**13.8 kV nominal; 15 kV maximum**] [**34.5 kV nominal; 38 kV maximum**] <**Insert other voltage**>.

Nominal Interrupting-Capacity Class: [**250**] [**350**] [**500**] [**750**] [**1000**] MVA.

Main-Bus Rating: [**1200 A**] [**2000 A**] [**3000 A**], continuous.

* + - * 1. Circuit Breakers: Electrically operated, drawout mounting; using three individual vacuum-sealed interrupter modules, and including the following features:

Designed to operate at rated voltage to interrupt fault current within its rating within [**three**] [**five**] cycles of trip initiation. For systems with X/R ratio of 17 or less, transient voltage during interruption shall not exceed twice the rated line-to-ground voltage of the system.

Contact-Wear Indicator: Readily accessible to field maintenance personnel.

Minimum of six Type A and six Type B spare contacts.

Interchangeability: Interchangeable with vacuum circuit breakers of same current and interrupting ratings.

Operating Mechanism: Electrically charged, mechanically and electrically trip-free, stored-energy operation.

* + - * 1. Control Power:

Retain one of two subparagraphs below to select from control power options. See Evaluations for discussion.

[**48**] [**125**] <**Insert voltage**>-V dc for closing and tripping.

Indicate location of remote alarm on Drawings.

Low-DC-Voltage Alarm: Monitor dc control power voltage with a remote alarm. Alarm shall sound if voltage falls to an adjustable value to indicate an impending battery failure. Factory set alarm value at 80 percent of full-charge voltage.

[**120**] [**240**] <**Insert voltage**>-V ac for closing and tripping.

* + - * 1. Test Accessories: Relay and meter test plugs.

Retain "Circuit-Breaker Test Cabinet" Paragraph below to comply with requirements of serving utility company or Owner's medium-voltage maintenance and testing.

* + - * 1. Circuit-Breaker Test Cabinet:

Separately mounted.

Containing push buttons for circuit-breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately 108 inches long.

Include secondary devices for operating circuit breaker if removed from switchgear and moved near test cabinet.

Include provision for storage of test and maintenance accessories in cabinet.

* + - * 1. Remote-Tripping Device: Wall-mounting emergency control station to open circuit breakers; located in red cast-metal box with break-glass operation.

Revise "Surge Arresters" Paragraph below to specify station or intermediate-class arresters if Project conditions require. Coordinate with Drawings. See Editing Instruction No. 2 in the Evaluations for discussion on applying surge arresters.

* + - * 1. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.
				2. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker test, inspection, maintenance, and operation.

Fuse-handling tool.

Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.

Racking handle to move circuit breaker manually between "connected" and "disconnected" positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

* + - 1. MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION
				1. Metal-enclosed, air-interrupter switchgear, [**with**] [**without**] fuses, complying with IEEE C37.20.3.

See Editing Instruction No. 3 in the Evaluations for guidance before retaining arc-resistant option in subparagraph below.

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

* + - * 1. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

Retain three subparagraphs below unless ratings are indicated on Drawings.

System Voltage: [**4.16 kV nominal; 4.76 kV maximum**] [**7.2 kV nominal; 15 kV maximum**] [**13.8 kV nominal; 15 kV maximum**] [**34.5 kV nominal; 38 kV maximum**] <**Insert other voltage**>.

Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.

Main-Bus Rating: [**600**] [**1200**] [**2000**] A, continuous.

* + - * 1. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

Rating: [**600**] [**1200**]-A continuous duty and load break.

Two-Time Duty-Cycle Fault Closing: [**25,000**] [**40,000**] asymmetrical amperes.

Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.

Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.

Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.

Protective Shields: Cover live components and terminals.

Fuse Mounts: Single-frame mounted and de-energized when switch is open.

Mechanical Interlock: Prevent opening of switch compartment door unless switchblades are open, and prevent closing switch if door is open.[**Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.**]

Window: Permits viewing switchblade positions when door is closed.

Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.

* + - * 1. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.

Retain "Current-Limiting Fuses" or "Expulsion Fuses" Subparagraph below.

Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.

Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.

Indicator integral with each fuse to show when it has blown.

Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

Revise "Surge Arresters" Paragraph below to specify station or intermediate-class arresters if Project conditions require.

* + - * 1. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.
			1. MEDIUM-VOLTAGE INSTRUMENTS SECTION
				1. Instrument Transformers: Comply with IEEE 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 "Multifunction Digital-Metering Monitor" Paragraph below to require conventional analog-meter installation.

* + - * 1. Multifunction Digital-Metering 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.

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 antiparallax 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.

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. Overcurrent and Ground-Fault Protective Relays: Multifunctional, solid-state microprocessor-based, medium-voltage relay, for operation from the specified control power. Comply with IEEE C37.90.

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

Primary Current-Transformer Ratings: Programmable from 5 to 5,000 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 ANSI 51 phase and ANSI 51 ground, and the other contact assigned ANSI 50 phase and ANSI 50 ground.

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

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

Communications module to transmit the following data.

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.

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. Provide a "protection off" alarm, which 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.

Retain first subparagraph below if control power is supplied at 120-V ac.

The relay shall operate reliably solely from the breaker main current transformers during a fault condition, if the normally connected auxiliary ac voltage is not available, even after an extended power outage.

Mount the relay in a drawout case with a two-stage quick-release operation. The 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 to provide alarm indication and tripping of circuit breaker upon removal of the relay from the case.

Insert other relay types in first paragraph below when adding other relays to operate circuit breakers in the medium-voltage switchgear section of the secondary unit substation. The 51/50 overcurrent relay described in "Overcurrent and Ground-Fault Protective Relays" Paragraph above is typical of microprocessor-based protective relays. Specify setting and testing of microprocessor-based relays for specific applications in "Field Quality Control" Article.

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

Retain one of two "Control Power Supply" paragraphs below. Coordinate with circuit-breaker tripping and relaying requirements.

* + - * 1. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices.

Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

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

Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

Retain one of first two subparagraphs below.

Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.

Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

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

* + - * 1. Control Power Supply: DC battery system.

Coordinate "System Requirements" Subparagraph 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.

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.

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

Coordinate first two subparagraphs below with Drawings.

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.**]

Accessories:

Thermometers with specific-gravity correction scales.

Hydrometer syringes.

Set of cell numerals.

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 N.O. 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. 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 according to NFPA 70 for duty required.

Retain one of or both "Liquid-Filled Transformer Section" and "Dry-Type Transformer Section" articles. If selecting both, indicate where installed on Drawings.

* + - 1. LIQUID-FILLED TRANSFORMER SECTION

UL compliance is an option not available from all manufacturers and for all kVA ratings.

* + - * 1. Description: IEEE C57.12.00 [**and UL 1062,**] liquid-filled, two-winding, secondary unit substation transformer.

Retain "Primary Incoming Section" Paragraph below for medium-voltage overhead wire connection to the transformer section.

* + - * 1. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.

Retain one of four "Insulating Liquid" paragraphs below. If less-flammable insulating liquid is required, delete first paragraph and retain one of three remaining paragraphs below; verify availability with selected secondary unit substation manufacturers. Transformer primary voltage must be 35 kV or less for less-flammable liquids. See Editing Instruction No. 4 in the Evaluations for discussion of transformer liquids.

* + - * 1. Insulating Liquid: Mineral oil complying with ASTM D3487, Type II, and tested according to ASTM D117.
				2. Insulating Liquid: Less flammable, edible-seed-oil based, and listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall be biodegradable and nontoxic.
				3. Insulating Liquid: Less flammable, dielectric, and listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall be biodegradable and nontoxic.
				4. Insulating Liquid: Less flammable, silicone-based dielectric, and listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall have low toxicity and be nonhazardous.

Retain one of two "Insulation Temperature Rise" paragraphs below.

* + - * 1. Insulation Temperature Rise: 55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.
				2. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

See the Evaluations for discussion of how BIL values relate to the primary voltage of the transformer.

* + - * 1. BIL: [**60**] [**75**] [**95**] [**110**] kV.

Retain one of two "Full-Capacity Voltage Taps" paragraphs below.

* + - * 1. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
				2. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

Retain class from options in "Cooling System" Paragraph below. See Editing Instruction No. 5 in the Evaluations for discussion of cooling classes.

* + - * 1. Cooling System: [**Class ONAN, liquid cooled**] [**Class ONAN/ONAF, liquid cooled, and with forced-air rating**] [**Class ONAN/ONAF/ONAF, liquid cooled, and with provisions for future forced-air rating**]. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.

Delete "Impedance" Paragraph below if manufacturer's standard impedance is adequate according to system analysis. See the Evaluations for typical impedance values. Revise to suit Project, and verify availability with manufacturers.

* + - * 1. Impedance: <**Insert value**> percent.
				2. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap.[**Include the following additional accessories:**]

Liquid-level gage.

Pressure-vacuum gage.

Liquid temperature indicator.

Drain and filter valves.

Pressure-relief device.

* + - 1. DRY-TYPE TRANSFORMER SECTION

Retain IEEE C57.12.50 for dry-type transformers rated up to 500 kVA, IEEE C57.12.51 for dry-type transformers rated 501 kVA and larger, or IEEE C57.12.52 for sealed dry-type transformers rated 501 kVA and larger.

* + - * 1. Description: IEEE C57.12.01, [**IEEE C57.12.50**] [**IEEE C57.12.51**] [**IEEE C57.12.52**], and dry-type, two-winding, secondary unit substation transformer.

Retain "Primary Incoming Section" Paragraph below for medium-voltage overhead wire connection to the transformer section.

* + - * 1. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.

Retain one of two "Style" paragraphs below. See Editing Instruction No. 6 in the Evaluations for discussion of cast-coil/encapsulated-coil and vacuum-pressure impregnated options.

* + - * 1. Style: [**Indoor, ventilated**] [**Outdoor, ventilated**] [**Totally enclosed, nonventilated**], cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
				2. Style: [**Indoor, ventilated**] [**Outdoor, ventilated**] [**Totally enclosed, nonventilated**], vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

Retain one of four "Cooling System" paragraphs below. See Editing Instruction No. 5 in the Evaluations for discussion of cooling classes.

* + - * 1. Cooling System: Class AA, air cooled, complying with IEEE C57.12.01.
				2. Cooling System: Class AFA, air cooled with forced-air rating, complying with IEEE C57.12.01.

Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.

Include mounting provision for fans.

* + - * 1. Cooling System: Class AA/AFA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.

Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.

Include mounting provision for fans.

* + - * 1. Cooling System: Class AFA, forced-air cooling, complying with IEEE C57.12.01.

Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.

Include cooling fans.

See the Evaluations for discussion on insulating materials and temperature-rise considerations in dry-type transformers.

* + - * 1. Insulation Materials: IEEE C57.12.01, rated [**220**] <**Insert number**> deg C.

Insulation Temperature Rise: [**80**] [**115**] [**150**] deg C, maximum rise above 40 deg C.

See the Evaluations for how BIL values relate to the primary voltage of the transformer.

* + - * 1. BIL: [**60**] [**75**] [**95**] [**110**] kV.

Retain one of two "Full-Capacity Voltage Taps" paragraphs below.

* + - * 1. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage.
				2. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.

Delete "Impedance" Paragraph below if manufacturer's standard impedance is adequate according to system analysis. See the Evaluations for discussion of typical impedance values.

* + - * 1. Impedance: <**Insert value**> percent.

If retaining "High-Temperature Alarm" Paragraph below, coordinate with Drawings and provide external power and signal connections.

* + - * 1. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.
			1. SECONDARY DISTRIBUTION SECTION TERMINAL COMPARTMENT
				1. Low-Voltage Terminal Compartment: Bus [**bars mounted on standoff insulators**] [**duct flange for close coupling with busway**].
			2. SECONDARY DISTRIBUTION SECTION SWITCHGEAR
				1. The secondary distribution section shall be drawout, [**fused**] [**fused where indicated**], low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.

Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

* + - * 1. Switchgear Structure:

Match and align the front and back of the switchgear.

Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.

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

Operate manual charging system.

Open and close the circuit breaker.

Examine and adjust the trip unit.

Read the breaker nameplate.

Locate instrumentation transformers within the breaker cell and make front accessible and removable.

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

* + - * 1. Switchgear Bus:

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

Main Phase Bus: Uniform capacity the entire length of section.

See Editing Instruction No. 7 in the Evaluations for a discussion on oversizing neutral bus.

Neutral Bus: [**50**] [**100**] percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.

Retain "Vertical Section Bus Size" Subparagraph below if switchgear assembly includes spare circuit breakers and spaces for future circuit breakers. See Editing Instruction No. 7 in the Evaluations.

Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.

Retain one of three "Phase- and Neutral-Bus Material" subparagraphs below for main-bus material, or delete all and make selection Contractor's option.

Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.

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.

Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.

Retain one of first two subparagraphs below as required by bus-material specification.

Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.

Use copper for connecting circuit-breaker line to copper bus.

Contact Surfaces of Buses: Silver plated.

Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches.

Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.

Retain "Neutral Disconnect Link" Subparagraph below for switchgear with main service disconnect switches. Coordinate with Drawings.

Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch copper bus, arranged to connect neutral bus to ground bus.

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

IEEE and UL standards may require air insulation only. Retain "Bus-Bar Insulation," "Sprayed Insulation Thickness," and "Bolted Bus Joints" subparagraphs below if insulated bus is required.

Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.

Sprayed Insulation Thickness: 3 mils, minimum.

Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

* + - * 1. Circuit-Breaker Compartment:

Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

Interlocks: Prevent movement 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.

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 the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.

Disconnected Position: Primary and secondary devices and ground contact disengaged.

Primary Disconnect: Mount on the stationary part of the compartment. The 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. The 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.

Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.

* + - * 1. Circuit Breakers:

Comply with IEEE C37.13 and UL 1066.

Coordinate "Ratings" Subparagraph below with Drawings.

Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

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

Normal Closing Speed: Independent of both control and operator.

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

Stored-Energy Mechanism: [**Manually charged**] [**Electrically charged**] [**Electrically charged, and the operator's choice of manual charging**].

Operating Handle: One for each circuit breaker capable of manual operation.

Electric Close Button: One for each electrically operated circuit breaker.

Operation counter.

Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

Revise first seven subparagraphs below to meet requirements of the overcurrent protective-device coordination study and the arc-flash study. Study requirements are specified in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."

Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.

Temperature compensation that ensures accuracy and calibration stability from minus 5 to plus 40 deg C.

Field-adjustable, time-current characteristics.

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

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

Pickup Points:

Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.

Five minimum, for instantaneous-trip functions.

Coordinate first subparagraph below with Drawings. Indicate circuits with ground-fault protection. Show type of protection for each circuit where switchgear has more than one type.

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

Retain one of first three subparagraphs below.

Arrange to provide protection for three-wire circuit or system.

Arrange to provide protection for four-wire circuit or system.

Arrange to provide protection for four-wire, double-ended substation.

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

Coordinate "Auxiliary Contacts" Paragraph below with Drawings.

Auxiliary Contacts:

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

Spare auxiliary switches, at least two, unless other quantity is 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.

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.

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

"Mechanical Interlocking of Circuit Breakers" Paragraph below limits competition, because some manufacturers will not provide mechanical interlocks. See Editing Instruction No. 8 in the Evaluations. Coordinate interlocking scheme with Drawings.

* + - * 1. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
				2. Key Interlocks: Arranged to prevent opening or closing interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.

Retain one of two "Undervoltage Trip Devices" paragraphs below.

* + - * 1. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.
				2. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

Locate shunt-trip and associated controls on Drawings.

* + - * 1. Shunt-Trip Devices.

Retain "Fused Circuit Breakers" Paragraph below for fused circuit breakers. Indicate fuse size on Drawings.

* + - * 1. Fused Circuit Breakers: Circuit-breaker and fuse combinations complying with requirements for circuit breakers and trip devices.

Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.

Circuit Breakers with Frame Size [**1600**] <**Insert number**> A and Smaller: Mount fuses on line side of associated circuit breaker[**, on a common drawout carriage**], arranged so fuses are accessible only when circuit breaker is in "disconnected" position.

Circuit Breakers with Frame Sizes More than [**1600**] <**Insert number**> A: Fuses and circuit breakers [**may**] [**shall**] be installed in separate compartments on separate drawout mountings. Interlock fuse drawout element with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in "open" position.

Open-Fuse Trip Device: Provide for a positive means of tripping and holding circuit breaker in "open" position when a fuse opens. Indicate open-fuse status [**at front of circuit breaker**] [**or**] [**fuse drawout element**].

* + - * 1. 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.
			1. SECONDARY DISTRIBUTION SECTION NETWORK PROTECTORS
				1. The secondary distribution section shall be composed of drawout, fused, low-voltage network protectors, complying with IEEE C57.12.44 and IEEE C37.20.1. The switch shall comply with UL 1066.

Rated for continuous service in an ambient temperature of up to 40 deg C, applied to three-phase, four-wire, solidly grounded wye secondary networks. Comply with IEEE C57.12.44.

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.

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

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

Control Voltage: 125 V.

Program the relay with factory default values. Provide one hand-held pendant to field adjust these values using relay calibration procedures. Include an anti-pumping program to lock the protector open under abnormal conditions.

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

* + - * 1. Coordinate and comply with requirements of the low-voltage switchgear supplied by the network.
				2. Controls: Microprocessor-based, three-phase network relay, with features and functions as follows:

The protector control shall use a positive and negative sequence-based algorithm for current and voltage.

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.

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.

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

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

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

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**] <**Insert number**> spare auxiliary contacts and an equal number of N.O. and N.C. types.

* + - * 1. Network Communications: Communicate the following network relay parameters:

Current in each phase.

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

Three-phase watts, vars, and va.

Frequency.

Power factor.

Network relay set points.

* + - * 1. Enclosure:

Coordinate plan and elevation Drawings with the requirements of first two subparagraphs below.

With top-mounted transition to connect to the low-voltage power network.

Retain one of two "Network Switchgear-Mounted Disconnect Switch" subparagraphs below.

Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted fuse truck, with Class L fuses rated for 200-kA interrupting capacity and key interlocked with each associated protector.

Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted main circuit breaker rated for fault current that can be delivered by the network transformers, less one. Use drawout type to provide a means of isolating the load side of each protector from the network bus.

* + - 1. LOW-VOLTAGE INSTRUMENT SECTION
				1. Instrument Transformers: Comply with IEEE 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 "Multifunction Digital-Metering Monitor" or "Analog Instruments" Paragraph below.

* + - * 1. Multifunction Digital-Metering 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.

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.

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

* + - * 1. Analog Instruments: Rectangular, 4-1/2 inches square, 1 percent accuracy, semiflush mounting, with antiparallax 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 demand interval and other characteristics in "Watt-Hour Meters" and "Recording Demand Meter" subparagraphs 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 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 interval.

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

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

* + - * 1. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

Retain one of two "Surge Suppression" paragraphs below. Choose between factory-installed or field-installed suppressors.

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

Integral disconnect switch.

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

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

Indicator light display for protection status.

Form-C contacts rated at 5-A 250-V ac, one N.O. and one N.C., 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.**]

Surge counter.

* + - * 1. Surge Suppression: Include the following features and accessories:

Integral disconnect switch.

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

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

Indicator light display for protection status.

Form-C contacts rated at 5-A 250-V ac, one N.O. and one N.C., 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.**]

Surge counter.

Retain one of two "Control Power Supply" paragraphs below.

* + - * 1. Control Power Supply: From the medium-voltage instruments section.
				2. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices.
				3. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.

Conductors sized according to NFPA 70 for duty required.

* + - * 1. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.

Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.

Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

Retain one of or both "Circuit-Breaker Removal Apparatus" subparagraphs below. Coordinate apparatus space requirements with Drawings.

Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

If "Circuit-Breaker Removal Apparatus" Subparagraph below is used for outdoor switchgear, it must be walk-in aisle type. Coordinate apparatus space requirements with Drawings.

Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.

Coordinate "Spare-Fuse Cabinet" Subparagraph below with Drawings.

Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

* + - 1. IDENTIFICATION DEVICES

Coordinate this article with Drawings.

* + - * 1. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws.
			1. SOURCE QUALITY CONTROL
				1. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to NEMA C 37.51.
				2. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

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

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

Polarity and phase relation on the rated voltage connection.

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

Exciting current at rated voltage on the rated voltage connection.

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

Applied potential.

Induced potential.

Tests in "Temperature Test" Subparagraph below are optional; select to suit Project conditions. If Project covers more than one unit of a given kVA rating, consider testing one unit only.

Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.

Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

Retain subparagraph below if Owner wants tests to be witnessed.

Director’s Representative will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.
				2. 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. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

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

* + - * 1. Verify that ground connections are in place.. Maximum ground resistance shall be 5 ohms at secondary unit substation location.
				2. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. INSTALLATION
				1. Comply with applicable portions of NECA 1, NECA 400, NECA 410, NECA 430, and NEMA SG 11.

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

* + - * 1. Install secondary unit substations on cast-in-place concrete equipment base(s).

Retain first paragraph below for interior installations. Indicate vibration isolation and seismic control device type and minimum deflection in supported equipment schedule on Drawings.

* + - * 1. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
			1. IDENTIFICATION
				1. Identify system components, wiring, cabling, and terminals.

Install the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

* + - * 1. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.
			1. CONNECTIONS
				1. At Interior Locations: For grounding-to-grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer 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.
				2. At Exterior Locations:

For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the transformer 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 feet. 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. CLEANING
				1. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.
			2. FIELD QUALITY CONTROL

Retain one of first four paragraphs below. Retain "Testing Agency" Paragraph below if Owner will hire an independent testing agency.

* + - * 1. Testing Agency: Director’s Representative will engage a qualified testing agency to perform tests and inspections.

Retain "Testing Agency" Paragraph below to require Contractor to hire an independent testing agency.

* + - * 1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

Retain "Manufacturer's Field Service" Paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a Company Service Advisor to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform tests and inspections" Paragraph below to require the Contractor to perform tests and inspection and retain the optional text to require Contractor to arrange for the assistance of a factory authorized service agent.

* + - * 1. Perform tests and inspections [**with the assistance of a Company Service Advisor**].

Retain test requirements below with any combination of paragraphs above. The following tests and inspections are derived from the NFPA 70B and the NETA ATS.

* + - * 1. 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 Ch. "Testing and Test Methods."

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

After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.

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

Visual and Mechanical Inspection:

Verify equipment nameplate data complies with Contract Documents.

Inspect bolted electrical connections for high resistance using one of the following two methods:

Use 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.

Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

Remove and replace malfunctioning units and retest.

Prepare test and inspection reports. Record as-left set points of all adjustable devices.

* + - * 1. Switchgear Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, grounding, and required area clearances.

Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to the address of the circuit breaker that is used to identify it in microprocessor-communication software.

Verify that current and voltage-transformer ratios correspond to Drawings.

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 all active components.

Inspect mechanical indicating devices for correct operation.

Verify that filters are in place and vents are clear.

Inspect control power transformers as follows:

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

Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.

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

Electrical Tests:

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 according to 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, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to 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-voltage 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-V 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 2 megohms.

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.

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.

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 Surge Arrester Field Tests:

Visual and Mechanical Inspection:

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 according to 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.

* + - * 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 according to manufacturer's published data.

Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism shall be according to 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 or both of first two subparagraphs below. 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 according to 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 according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to 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 which 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 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 according to manufacturer's published data. Minimum pickup voltage of the trip and close coils shall comply with manufacturer's published data. In the absence of 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 according to manufacturer' published data.

Trip circuit breaker by operation of each protective device. Reset all 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 meet manufacturer's published data.

Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position according to 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 according to 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:

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.

Verify that 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:

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, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS, Table 100.5.

Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.

Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall comply with IEEE C57.13.

Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or shall comply with IEEE C57.13.1.

Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. The measured burdens shall match the instrument transformer Accuracy Class rating.

Retain insulation-resistance test in first subparagraph below if Project conditions require. This test is normally considered an optional field test.

Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall comply with NETA ATS, Table 100.5. The insulation-resistance value shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.

Retain dielectric-withstand-voltage tests in first subparagraph below if Project conditions require. This test is normally considered an optional field test.

Perform dielectric-withstand-voltage tests on the primary winding with the secondary grounded. Test voltages shall comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application, the primary winding is considered to have passed the test.

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

In first subparagraph below, indicate the grounding point on Drawings.

Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

Electrical Tests of Voltage and Potential Transformers:

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute according to NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS, Table 100.5. Insulation-resistance values of the transformers shall not be less than values shown in NETA ATS, Table 100.5.

Perform a polarity test on each transformer to verify the polarity marks or H(1)-X(1) relationship. Polarity results shall agree with transformer markings.

Perform a turns-ratio test on all tap positions. Ratio errors shall not exceed the tolerances specified in IEEE C57.13.

Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings. The measured burdens shall match the instrument transformer Accuracy Class rating.

Retain the dielectric-withstand-voltage test below if Project conditions require. This test is normally considered an optional field test.

Perform a dielectric-withstand-voltage test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall comply with NETA ATS, 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-voltage test, the primary windings are considered to have passed the test.

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

In subparagraph below, indicate the grounding point on Drawings.

Verify that voltage-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

* + - * 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 according to manufacturer's instructions.

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 according to 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:

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.

Loss of Field (Impedance) Relay:

Determine maximum reach.

Determine maximum torque angle.

Determine offset.

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

Plot impedance circle.

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 N.O. contact.

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

Verify negative sequence trip.

Determine time delay to close the N.O. contact with sudden application of 120 percent of pickup.

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

Thermal Replica Relay:

Determine time delay at 300 percent of setting.

Determine a second point on the operating curve.

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

Determine pickup.

Temperature (RTD) Relay:

Determine trip resistance.

Determine reset resistance.

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.

Power-Factor Relay:

Determine tripping angle.

Determine time delay.

Overvoltage Relay:

Determine overvoltage pickup.

Determine time delay to close the contact with sudden application of 120 percent of pickup.

Voltage Balance Relay:

Determine voltage difference to close the contacts with one source at rated voltage.

Plot the operating curve for the relay.

Transformer Sudden Pressure Relay:

Determine rate-of-rise or the pickup level of suddenly applied pressure according to manufacturer's published data.

Verify operation of the 63 FPX seal-in circuit.

Verify trip circuit to remote operating device.

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.

Reclosing Relay:

Determine time delay for each programmed reclosing interval.

Verify lockout for unsuccessful reclosing.

Determine reset time.

The pulse duration determination in first subparagraph below is normally considered an optional field test.

Determine close pulse duration.

Verify instantaneous overcurrent lockout.

Frequency Relay:

Verify frequency set points.

Determine time delay.

Determine undervoltage cutoff.

Pilot Wire Monitor:

Determine overcurrent pickup.

Determine undercurrent pickup.

Determine pilot wire ground pickup level.

Differential:

Determine operating unit pickup.

Determine the operation of each restraint unit.

Determine slope.

Determine harmonic restraint.

Determine instantaneous pickup.

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

Plot operating characteristics for each restraint.

Control Verification:

Functional Tests:

Check operation of all active digital inputs.

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

Check internal logic functions used in protection scheme.

For pilot schemes, perform a loop-back test to check receive and transmit communication circuits.

For pilot schemes, perform satellite synchronized end-to-end tests.

For pilot schemes with direct transfer trip (DTT), perform transmit and received DTT at each terminal.

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 1188.

Measure charger float and equalizing voltage levels. Charger float and equalizing voltage levels shall be according to 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 according to 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 according to manufacturer's published data or IEEE 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 according to 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 according to manufacturer's published data or IEEE 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. DC System Charger Field Test:

Visual and Mechanical Inspection:

Inspect for physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify the unit is clean.

Inspect filter and tank capacitors.

Verify operation of cooling fans and presence of filters.

Electrical Tests:

Verify float voltage, equalizing voltage, and high-voltage shutdown settings. Float and equalizing voltage settings shall be according to battery manufacturer's published data.

Verify current limit. Current limit shall be within manufacturer's recommended maximum.

Verify operation of alarms. Results of alarm operation shall be according to manufacturer's published data and system design.

Measure and record input and output voltage and current. Input and output voltage shall be according to manufacturer's published data.

Measure and record ac ripple current and voltage imposed on the battery. AC ripple current and voltage imposed on the battery shall be according to manufacturer's published data.

The charger test in subparagraph below is normally considered an optional field test.

Perform full-load testing of charger. Charger shall be capable of manufacturer's specified full load.

* + - * 1. Liquid-Filled Transformer Section Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect impact recorder prior to unloading.

Test dew point of tank gases if applicable.

Inspect anchorage, alignment, and grounding.

Verify the presence of PCB content labeling.

Verify removal of any shipping bracing after placement.

Verify the bushings are clean.

Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.

Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.

Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.

Perform specific inspections and mechanical tests recommended by the manufacturer.

Verify presence of transformer surge arresters and that their ratings are as specified.

Verify that as-left tap connections are as specified.

Verify the presence of surge arresters and that their ratings are as specified.

Electrical Tests:

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.

Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.

Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.

Retain power-factor test in first subparagraph below if the importance of the load served by the transformer warrants. This is normally considered an optional test.

Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.

Retain one or more of first four subparagraphs below if those tests are not included in "Source Quality Control" Article. Turns-ratio, excitation-current, winding-resistance, and applied-voltage tests are normally considered optional field tests.

Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.

Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.

Measure the resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.

Perform an applied-voltage test on high- and low-voltage windings-to-ground.

Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

Remove a sample of insulating liquid according to ASTM D923. Insulating liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:

Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.

Acid Neutralization Number: ASTM D974.

Retain "Specific Gravity" Subparagraph below if Project conditions require. This is normally considered an optional field test.

Specific Gravity: ASTM D1298.

Interfacial Tension: ASTM D971.

Color: ASTM D1500.

Visual Condition: ASTM D1524.

Retain water-in-insulating-liquid test in "Water in Insulating Liquids" Subparagraph below for transformers 25 kV and higher, and for all silicone-based liquids. For others, this is normally considered an optional field test.

Water in Insulating Liquids: ASTM D1533.

Retain the power-factor or dissipation-factor test in "Power Factor or Dissipation Factor" Subparagraph below if Project conditions require. This is normally considered an optional field test.

Power Factor or Dissipation Factor: ASTM D924.

Remove a sample of insulating liquid according to ASTM D923 and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D3612.

For testing dry-type, medium-voltage transformers that are part of a secondary unit substation, retain one of or both dry-type transformer section field tests paragraphs below. If retaining both, add a descriptive word ("large" and "small") to the paragraph title; otherwise, delete optional text.

Retain "(Small )Dry-Type Transformer Section Field Tests" Paragraph below for power transformers with windings rated higher than 600 V and low-voltage transformers larger than 167-kVA single phase or 500-kVA three phase.

* + - * 1. [**Small**]Dry-Type Transformer Section Field Tests:

Visual and Mechanical Inspection.

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify that resilient mounts are free and that any shipping brackets have been removed.

Verify the unit is clean.

Perform specific inspections and mechanical tests recommended by the manufacturer.

Verify that as-left tap connections are as specified.

Verify the presence of surge arresters and that their ratings are as specified.

Electrical Tests:

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.

Retain turns-ratio test in first subparagraph below if not included as a factory test in "Source Quality Control" Article, and if the importance of the transformer warrants such a test.

Perform turns-ratio tests at all tap positions. The test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.

Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

Retain "(Large )Dry-Type Transformer Section Field Tests" Paragraph below for power transformers with windings rated higher than 600 V and low-voltage transformers less than 167-kVA single phase or 500-kVA three phase.

* + - * 1. [**Large**]Dry-Type Transformer Section Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify that resilient mounts are free and that any shipping brackets have been removed.

Verify the unit is clean.

Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.

Verify that cooling fans operate and that fan motors have correct overcurrent protection.

Perform specific inspections and mechanical tests recommended by the manufacturer.

Verify that as-left tap connections are as specified.

Verify the presence of surge arresters and that their ratings are as specified.

Electrical Tests:

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.

Perform power-factor or dissipation-factor tests on windings according to the test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:

2.0 percent for power transformers.

5.0 percent for distribution transformers.

Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.

Retain power-factor test in first subparagraph below if the importance of the load served by the transformer warrants. This is normally considered an optional test.

Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV. Tip-up test result exceeding 1.0 percent shall be investigated.

Retain one or more of first four subparagraphs below if not included in "Source Quality Control" Article. Turns-ratio, excitation-current, winding-resistance, and applied-voltage tests are normally considered optional field tests.

Perform turns-ratio tests at all tap positions. The test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.

Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.

Measure the resistance of each winding at each tap connection.

Perform an applied-voltage test on all high- and low-voltage windings-to-ground. The ac dielectric-withstand-voltage test result shall not exceed 75 percent of factory test voltage for one-minute duration. The dc dielectric-withstand-voltage test result shall not exceed 100 percent of the ac rms test voltage for one-minute duration. 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 correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

* + - * 1. Secondary Distribution Section Network Protector Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify the unit is clean.

Verify arc chutes are intact.

Inspect moving and stationary contacts for condition and alignment.

Verify that maintenance devices are available for servicing and operating the network protector.

Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the network protector are correct.

Perform mechanical operator and contact alignment tests on both the network protector and its operating mechanism. Operations counter shall advance one digit per close-open cycle.

Verify cell fit and element alignment.

Verify racking mechanism operation.

Verify manufacturer's recommended lubrication on moving current-carrying parts and on moving and sliding surfaces.

Record as-found and as-left operation counter readings.

Perform a leak test on submersible enclosure according to manufacturer's published data.

Electrical Tests:

Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with network protector closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1.

Insulation-resistance values of bus insulation shall be according to 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 Table 100.1.

Do not conduct insulation-resistance tests of control wiring until insulation-resistance levels of the power circuits are raised above minimum values.

Perform a contact/pole-resistance test. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in manufacturer's published data. In the absence of manufacturer's published data, investigate values that deviate from adjacent poles or similar protectors by more than 50 percent of the lowest value.

Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V 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 manufacturer's recommendation.

Minimum insulation-resistance values of control wiring shall not be less than 2 megohms.

Verify current-transformer ratios according to IEEE C57.13.

Measure the resistance of each network protector power fuse. Investigate and correct fuse-resistance values that deviate from each other by more than 15 percent.

Measure minimum pickup voltage of the motor-control relay. Minimum pickup voltage of the motor-control relay shall be according to manufacturer's published data, but not more than 75 percent of rated control circuit voltage.

Verify that the motor can charge the closing mechanism at the minimum voltage specified by the manufacturer. Minimum operating voltage of the motor on the closing mechanism shall not exceed 75 percent of rated control circuit voltage.

Measure minimum pickup voltage of the trip actuator. Trip actuator minimum pickup voltage shall not exceed 7.5 percent of rated control circuit voltage. Verify that the actuator resets correctly.

Calibrate the network protector relays according to "Medium-Voltage Instruments Section" Article, "Overcurrent and Ground-Fault Protective Relays" Paragraph, specifying microprocessor-based protective relays.

Perform the following operational tests:

Verify correct operation of all mechanical and electrical interlocks.

Verify trip-free operation.

Verify correct operation of the auto-open-close control handle.

Verify the protector will close with voltage on the transformer side only.

Verify the protector will open when the source feeder breaker is opened.

Verify phase rotation, phasing, and synchronized operation.

* + - * 1. Low-Voltage Power Circuit-Breaker Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify that all maintenance devices are available for servicing and operating the breaker.

Verify the unit is clean.

Verify that the arc chutes are intact.

Inspect moving and stationary contacts for condition and alignment.

Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism according to 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.

Perform adjustments for final protective-device settings according to coordination study provided by end user.

Record as-found and as-left operation counter readings.

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 according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.

Measure contact resistance across each power contact of the circuit breaker. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in 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.

Determine long-time pickup and delay by primary current injection. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS, Table 100.7.

Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

Determine instantaneous pickup value by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.

Test functions of the trip unit by means of secondary injection. Pickup values and trip characteristic shall be as specified and within manufacturer's published tolerances.

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

Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.

Verify operation of charging mechanism. The charging mechanism shall operate according to manufacturer's published data.

* + - * 1. Metering Device Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

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:

Verify accuracy of meters at cardinal points. Meter accuracy shall be according to manufacturer's published data.

Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.

Verify instrument multipliers. Instrument multipliers shall be according to 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. FOLLOW-UP SERVICE
				1. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Director’s Representative, but not more than six months after Final Acceptance, 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 secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology 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 any 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 transformer taps.

Rebalance loads.

Prepare written request for voltage adjustment by electric utility.

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

Report:

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

For each relay and adjustable circuit breaker, tag the device with adjusting technician's initials and the date of the adjustment. Record the settings and file with test records specified in "Field Quality Control" Article.

* + - * 1. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary 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 unit substation.

Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

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

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

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 according to 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 261116.11