SECTION 261116.12 - SECONDARY UNIT SUBSTATIONS WITH SWITCHBOARDS 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 switchboard section, with the following features:

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

Medium-voltage, 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. ICCB: Insulated-case circuit breaker.
        3. MCCB: Molded-case circuit breaker.
        4. NETA ATS: Acceptance testing specification.
        5. PCB: Polychlorinated biphenyl.
        6. SPD: Surge protective device.
      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.

* + - * 1. Design Data:

Curves in "Time-Current Characteristic Curves" paragraph below are required to coordinate devices upstream and downstream from secondary unit substation.

Time-Current Characteristic Curves: For overcurrent protective devices.

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.
        2. Coordination Drawings.

Retain "Outdoor Installations" subparagraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate 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.

Outdoor Installations:

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

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**].

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.

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

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

* + - * 1. Seismic Qualification Data: Certificates, for 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.

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

* + - * 1. 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. 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 will 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 with 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. 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:](http://www.specagent.com/Lookup?ulid=9250) 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 (Electrification Products Division)](http://www.specagent.com/Lookup?uid=123457175480).

[Eaton](http://www.specagent.com/Lookup?uid=123457141103).

[Schneider Electric USA (Square D)](http://www.specagent.com/Lookup?uid=123457141106).

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

* + - * 1. Seismic Performance: The 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
         1. Indoor Unit Arrangement: Single assembly.
         2. Outdoor Unit Arrangement: Single assembly.

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

Aisleless 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, galvanized steel, listed for installation outdoors, complying with IEEE C37.20.1. Aisleless, full-height doors, with provisions for padlocking, in front of basic weatherproof equipment. Integral structural-steel base frame with factory-applied asphaltic undercoating.

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.

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

Weatherproof ground-fault circuit interrupter duplex receptacle.

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

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

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 SG4 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.
      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 1A**] [**Type 2A**] [**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 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 switch-blade 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 and Current Transformers: Burden and Accuracy Class suitable for connected meters.

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.

* + - 1. LIQUID-FILLED TRANSFORMER SECTION
         1. Description: IEEE C57.12.00 and UL 1062, liquid-filled, two-winding, secondary unit substation transformer.

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 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; 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/FA, 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 SWITCHBOARD
         1. The secondary distribution section shall be drawout, [**fused**] [**fused where indicated**], low-voltage switchgear, complying with NEMA PB 2 and UL 891.
         2. Switchboard Structure: Front and rear accessible.

Match and align the [**front**] [**front and rear**] of the switchgear.

Retain subparagraph below if the secondary of the unit substation is a service entrance.

Comply with UL requirements for service entrance equipment.

"Switchboard 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. Switchboard 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.

Vertical Section Bus: Extend to spaces for future circuit breakers.

Retain one of two "Phase- and Neutral-Bus Material" subparagraphs below for main-bus material, or delete both 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: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.

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.

* + - * 1. Switchboard Arrangement:

Retain one of five options in "Main Disconnect Device(s)" subparagraph below that meets load and fault-current interrupting requirements.

Main Disconnect Device(s): [**Power circuit breakers**] [**Bolted pressure switches**] [**ICCBs**] [**MCCBs**] [**Fusible switches**].

Feeder Protective Devices: [**Bolted pressure switches**] [**ICCBs**] [**MCCBs**] [**Fusible switches**].

* + - * 1. Power Circuit Breakers: [**Fixed**] [**Drawout**] mounted, electrically operated air-circuit breakers, complying with UL 1066.

With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator shall not exceed 8 seconds. Operator power shall be from a control power transformer internal to the switchboard.

Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.

LED indicators or display, with manual reset, to show cause of automatic trip.

Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.

Trip the circuit breaker when closing on a fault.

Time-current adjustments to achieve protective-device coordination as follows:

Adjustable long-delay pickup and time.

Individual adjustments for short-delay pickup, time, and I-squared-t setting.

Adjustable instantaneous pickup.

Individually adjustable ground-fault pickup and time, with [**I-squared-t setting**] [**ground alarm**].

One test kit to test each trip function.

Battery backup for informational displays after automatic trip, with battery status indicator LED.

* + - * 1. Bolted Pressure Switches: Fixed-mounted, manually operated, [**electrically tripped,**] [**fusible,**]bolted pressure contact switch. Comply with UL 977.

Stored energy deadfront mechanism, compressed and released by the operating handle; switching action shall be independent of the speed of the operating handle.

Indication whether the switch is open or closed, and provisions for padlocking the operating handle.

With fuse clips and fuses for UL 248 Class L time-delay fuses.

Electrically tripped switches shall include:

Ground-fault protection, with adjustable time delay and test panel.

Single-phase protection, tripping the switch on loss of a source phase.

Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

* + - * 1. ICCBs: [**Fixed**] [**Drawout**]-mounted, [**manually**] [**electrically**] operated air-circuit breakers. Comply with UL 1066.

With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator shall not exceed 8 seconds. Operator power shall be from a control power transformer internal to the switchboard.

Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.

LED indicators or display, with manual reset, to show cause of automatic trip.

Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.

Trip the circuit breaker when closing on a fault.

Time-current adjustments to achieve protective-device coordination as follows:

Adjustable long-delay pickup and time.

Individual adjustments for short-delay pickup, time, and I-squared-t setting.

Adjustable instantaneous pickup.

Individually adjustable ground-fault pickup and time, with [**I-squared-t setting**] [**ground alarm**].

With built-in connector to test the breaker settings. Provide one test set.

Battery backup for informational displays after automatic trip, with battery status indicator.

* + - * 1. MCCBs (to 2500 A): Fixed-mounted, manually operated air-circuit breakers. Comply with UL 489.

With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.

Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.

With trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.

Time-current adjustments to achieve protective-device coordination as follows:

Adjustable long-time delay.

Adjustable short-time setting and delay to shape the time-current curve.

Adjustable instantaneous setting.

Individually adjustable ground-fault setting and time delay.

With built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker.[**Provide one test set for testing the installed circuit breakers 225-ampere frame and higher.**]

Ammeter in subparagraph below is normally considered an optional feature and may not be available from all listed manufacturers.

With built-in digital ammeter display, showing load current and tripping cause.

"MCCBs (1600 to 2500 A)" paragraph below is generally available for larger frame sizes for applications requiring additional time-current tripping features.

* + - * 1. MCCBs (1600 to 2500 A): Fixed-mounted, manually operated air-circuit breakers. Comply with UL 489.

With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.

Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.

LED indicators or display, with manual reset, to show reasons of automatic trip.

Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.

Trip the circuit breaker when closing on a fault.

Time-current adjustments to achieve protective-device coordination as follows:

Adjustable long-delay pickup and time.

Individual adjustments for short-delay pickup, time, and I-squared-t setting.

Adjustable instantaneous pickup.

Individually adjustable ground-fault pickup and time, with [**I-squared-t setting**] [**ground alarm**].

One test kit to test each trip function.

Battery backup for informational displays after automatic trip, with battery status indicator.

Electrical trip for fusible switches in "Fusible Switches" paragraph below is generally available for switches 400 A and larger.

* + - * 1. Fusible Switches: Fixed-mounted, manually operated, [**electrically tripped,**]fusible, quick-make, quick-break switch. Comply with UL 98.

Indication whether the switch is open or closed, and provisions for padlocking the operating handle.

With fuse clips and fuses.

Electrically tripped switches shall include:

Shunt trip.

Ground-fault protection, with adjustable time delay and test panel.

Single-phase protection, tripping the switch on loss of a source phase.

Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

* + - 1. LOW-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" 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.
        2. 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 and 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. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices.
        2. 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 switchboard.

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

If retaining "Circuit-Breaker Removal Apparatus" subparagraph 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.

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 C37.51.
         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. 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 shall 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 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-use 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.

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. 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 all required grounding and shorting connections provide contact.

Verify correct operation of transformer withdrawal mechanism and grounding operation.

Verify correct primary- and secondary-fuse sizes for voltage transformers.

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

Electrical Tests of Current Transformers:

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 tests 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 dielectric-withstand-voltage test in first subparagraph 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 relays. 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 all analog inputs, and verify correct registration of the relay meter functions.

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

* + - * 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 the "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 all 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. 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, 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. 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 the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

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 the 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, antipump function, and trip unit battery condition. Reset all 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. Insulated-Case/Molded-Case Air-Circuit-Breaker Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage and alignment.

Verify the unit is clean.

Operate the circuit breaker to ensure smooth operation.

Inspect operating mechanism, contacts, and arc chutes in unsealed units.

Perform adjustments for final protective-device settings according to the coordination study.

Electrical Tests:

Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with the circuit breaker 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. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.

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 the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

Determine long-time 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, including adjustment factors.

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 time 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 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.

Trip unit test in first subparagraph below is normally considered an optional field test.

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 the manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.

Verify correct operation of 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 all 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. Low-Voltage Ground-Fault Protection System Field Tests:

Visual and Mechanical Inspection:

Inspect the components for damage and errors in polarity or conductor routing.

Verify that ground connection is made on the source side of the neutral disconnect link and on the source side of any ground-fault sensor.

Verify that the neutral sensors are connected with correct polarity on both primary and secondary.

Verify that phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.

Verify that grounding conductors do not pass through zero sequence sensors.

Verify that grounded conductor is solidly grounded.

Verify the unit is clean.

Operate the circuit breaker to ensure smooth operation.

Verify correct operation of functions of the self-test panel if provided.

Verify that the control power transformer has adequate capacity for the system.

Set pickup and time-delay settings according to "Quality Control" Article.

Electrical Tests:

Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace the neutral disconnect link after testing. System neutral-to-ground insulation resistance shall be a minimum of 1 megohm. Correct wiring until the minimum is achieved.

Perform ground-fault protective-device pickup tests using primary injection. Results of pickup test shall be greater than 90 percent of the ground-fault protective-device pickup setting and less than 1200 A or 125 percent of the pickup setting, whichever is smaller. Adjust or replace the device until these parameters are achieved.

For summation-type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current-transformer pair. This test also applies to MCCBs utilizing an external neutral current transformer. The ground-fault protective device shall operate when current direction is the same relative to polarity marks in the two current transformers. The ground-fault protective device shall not operate when current direction is opposite relative to polarity marks in the two current transformers.

Measure time delay of the ground-fault protective device at a value equal to or greater than 150 percent of the pickup value. Relay timing shall be according to manufacturer's published data but shall be no longer than one second at 3000 A.

Verify reduced control voltage tripping capability is 55 percent for ac systems and 80 percent for dc systems. Replace the ground-fault system if the reduced control voltage tripping requirement is not achieved, and retest.

Retain zone-blocking test in subparagraph below if this feature has been added to Section Text.

Verify blocking capability of zone interlock systems. Results of zone-blocking tests shall be according to manufacturer's published data and design specifications.

* + - * 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 all 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 all 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 the 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 deg C at 30 deg C.

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

Description of equipment to be tested.

Discrepancies.

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

Probable cause of temperature difference.

Areas inspected. Identify inaccessible and unobservable areas and equipment.

Identify load conditions at time of inspection.

Provide photographs and thermograms of the deficient area.

Act on inspection results 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 261116.12