SECTION 26 23 00 – LOW-VOLTAGE SWITCHGEAR

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

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

1. Switchgear structure.
2. Requirements for indoor switchgear.
3. Circuit breakers.
4. Zone-selective interlocking.
5. Network protectors.
6. Surge suppression.
7. Control power supply, 120V ac.
8. Instrumentation and control.
9. Maintenance tools.
10. Identification.
11. Source quality control.

B. Related Requirements: Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for submetering.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For low-voltage switchgear.

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

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
5. Indicate short-time and short-circuit current rating of switchgear assembly.
6. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include mimic-bus diagram.

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

1. Comply with Section 260572 "Overcurrent Protective Device Short-Circuit Study" and Section 260573.16 "Coordination Studies."
2. For differential ground-fault protection scheme. Include wiring diagram of differential system along with test procedure recommended by UL 1558, using high-current injection equipment.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include following:
    a. Time-current curves (on full-size logarithmic paper) of main secondary breaker and largest secondary feeder device.
    b. Lists of spare parts and replacement components recommended for storage at Project site.
    c. Detailed instructions covering operation under both normal and abnormal conditions.
    d. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on USB storage device of hard-copy Submittal.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every 3 of each type and rating, but no fewer than 3 of each for following:

a. Potential transformers.

b. Control power circuits.

2. Draw out Circuit Breakers: One of each type and rating used for feeder circuit breakers in switchgear.

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

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

1.8 FIELD CONDITIONS

A. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than minus 22 degrees F and not exceeding 104 degrees F.

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

3. Effect of solar radiation is insignificant.

1.9 FIELD CONDITIONS

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Low-voltage switchgear shall be manufactured by ABB, Eaton, Schneider Electric, or Siemens.

2.2 SYSTEM DESCRIPTION

A. Description: Metal-enclosed, low-voltage switchgear with draw-out power circuit breakers, with accessories and metering components.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C37.20.1.
3. Listed and labeled as complying with UL 1558.
4. Listed and labeled for use as service entrance equipment.

2.3 PERFORMANCE REQUIREMENTS

A. Capacities and Characteristics:

1. Nominal System Voltage: 480/277V, 4-wire, 60 hertz.
2. Rated Power Frequency: 60 hertz.
3. Rated Insulation Level: Power frequency withstand shall be not less than 2.2-kV rms.
4. Rated Continuous Current:
    a. Main-Bus Continuous: As indicated.
    b. Vertical Section Bus Riser: Equal to frame size of low-voltage power circuit breaker connected to that riser.
5. Rated Short-Circuit Withstand Current: As indicated.
6. Short-Time and Short-Circuit Current: Match rating of integrated short-circuit current rating.

2.4 SWITCHGEAR STRUCTURE

A. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker. Extend section barriers between main and tie circuit breakers to rear of section. Barriers shall be rated for minimum 68 calories per square centimeter of incident arc flash energy.

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

1. Operate manual charging system.
2. Open and close circuit breaker.

3. Examine and adjust trip unit.
4. Read breaker nameplate.

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

D. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity entire length of assembly.
3. Neutral Bus: 100 percent of phase-bus ampacity unless otherwise indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
4. Ground Bus: Uniform capacity entire length of assembly, with pressure connector terminations for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches.
5. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
6. Bus Material and Connections:
    a. Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.
    b. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
    c. Contact Surfaces of Buses: Silver plated.
    d. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
7. Neutral Disconnect Link: Bolted, uninsulated, bus, arranged to connect neutral bus to ground bus.
8. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

E. Circuit-Breaker Compartment:

1. Draw-out Features: Circuit-breaker mounting assembly equipped with racking mechanism to position circuit breaker and hold it rigidly in connected, test, disconnected, and withdrawn positions. Include following features:
    a. Provide circuit-breaker racking system with positive stops at connected, test, disconnected, and withdrawn positions.
    b. Interlocks: Prevent racking of circuit breaker to or from connected position when it is closed and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
    c. Circuit-Breaker Positioning: Permit racking of open circuit breaker to or from connected, test, and disconnected positions only when compartment door is

closed unless live parts are covered by full dead-front shield. Permit manual withdrawal of open circuit breaker to position for removal from structure. When compartment door is open, status for connection devices for different positions includes following:

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

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

d. Primary Disconnect: Mount on stationary part of compartment. Disconnect shall consist of set of contacts extending to rear through insulating support barrier, and of corresponding moving finger contacts on power circuit-breaker studs, which engage in only connected position. Assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in rear cable compartment.

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

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

g. Place 2500A frame and larger circuit breakers at bottom of switchgear.

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

1. Bus transition sections.

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

2.5 ADDITIONAL REQUIREMENTS FOR INDOOR SWITCHGEAR

A. Enclosure Rating: Indoor.

B. Enclosure Material: Steel.

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

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

2.6 CIRCUIT BREAKERS

A. Draw-out type, unfused, power operated, with electronic trip devices. Comply with IEEE C37.13, IEEE C37.13a, and UL 1066.

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

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

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

1. Normal Closing Speed: Independent of both control and operator.
2. Slow Closing Speed: Optional with operator for inspection and adjustment.
3. Stored-Energy Mechanism: Manually charged.
    a. Operating Handle: One for each circuit breaker capable of manual operation.
    b. Electric Close Button: One for each electrically operated circuit breaker.
4. Provide interlock to discharge stored energy mechanism before circuit breaker can be withdrawn from its compartment.
5. Operation counter.

D. Operator Display: Located on face of circuit breaker.

1. Electrical operation buttons to open and close circuit breaker. Provide clear lockable cover over buttons.
2. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. Energized or hot condition shall be indicated by red light. De-energized, open, and safe condition shall be indicated by green light.
3. Indicator to show position of circuit-breaker contacts, status of closing springs, and circuit-breaker position in its compartment.
4. Provide "charged-not OK to close" indicator when closing springs are charged but circuit breaker is not ready to close.

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

1. Programmable functions independent of each other in both action and adjustment.
    a. Long-time setting.
    b. Long-time-delay with selectable I2T or I4T curve shaping.
    c. Short-time setting.
    d. Short-time-delay with flat or selectable I2T curve shaping.
    e. Instantaneous trip.
2. Field-adjustable, time-current characteristics.
3. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or combination of these methods.
4. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
5. Pickup Points:
    a. Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-T operation.
    b. Five minimum, for instantaneous-trip functions.

F. Ground-Fault Protection:

1. Ground-fault protection with at least 3 short-time-delay settings and 3 trip-time-delay bands; adjustable current pickup.

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

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

H. Shunt-Trip Devices.

I. Auxiliary Contacts:

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

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

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

K. Padlocking Provisions: For installing at least 3 padlocks on each circuit breaker to secure its enclosure and prevent movement of draw-out mechanism.

2.7 ZONE-SELECTIVE INTERLOCKING

A. Trip units for circuit breakers 1200A frame size and larger shall include zone-interlocking capability for short-time delay and ground-fault delay trip functions for system coordination and arc energy reduction. Zone-interlocking system shall restrain tripping of upstream circuit breaker and allow circuit breaker closest to fault to trip with no intentional time delay. In event that downstream breaker does not trip, upstream breaker shall trip after preset time delay. Zone-interlock system shall be factory wired and tested for circuit breakers within switchgear.

2.8 SURGE SUPPRESSION

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

1. Integral disconnect switch.

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

3. Indicator light display for protection status.

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

5. Surge counter.

2.9 CONTROL POWER SUPPLY, 120V AC

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

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

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

2.10 INSTRUMENTATION AND CONTROL

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

B. Ethernet Connectivity:

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

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

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

4. Server Configuration:

a. Initial network parameters set using standard web browser. Connect via local operator interface, or RJ-45 port accessible from front of equipment.

b. Network server shall be factory programmed with embedded HTML-formatted web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using standard web browser.

c. Password-protected login, with password administration accessible from LAN using standard web browser.

d. Operating Software: Suitable for local access; firewall protected.

5. Serial communications devices within equipment shall be addressed at factory and tested.

C. Instrument Transformers: Comply with IEEE C57.13. Instrument transformers may not be used for power to convenience receptacles and lighting.

1. Potential Transformers: Secondary voltage rating of 120V and NEMA C12.11 Accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy class suitable for connected relays, meters, and instruments.

D. Power Monitoring: Separately mounted, modular, permanently installed, solid-state, digital I/O multifunction metering instrument for power and energy metering and monitoring, complying with UL 61010-1.

1. Capable of metering 4-wire Y power systems.
2. Equipped with security lock to protect revenue-related metering from unauthorized and accidental changes.
3. Comply with IEC 60529 degree of protection code of IP65 for front of meter, and code of IP30 for body.
4. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
5. Accuracy:
    a. Comply with ANSI C12.20, Class 0.5.
    b. Neutral Current Measurement: Not more than 0.65 percent.
    c. Power Factor: 1.0 percent.
    d. Frequency: 0.1 percent.
    e. THD: 1.0 percent.
    f. Waveform Sampling: 64 per cycle.
6. Data Link: Ethernet connectivity specified in this article.
7. Meter Physical Characteristics:
    a. Display: Backlit LCD with antiglare and scratch-resistant lens.
    b. Display of Metered Values: One screen to show at least 3 user-selected values displayed at same time. Selections available to display shall include following:
        1) Meters.
        2) Measurements.
        3) THD.
        4) Energy.
        5) Demand.
        6) Minimum and maximum values.
        7) Power demand.
8. Sampling Rate: Continuously sample and record voltage and current at rate not less than 64 samples per cycle, simultaneously on voltage and current channels of meter.
9. Meters:
    a. Instantaneous, rms:
        1) Current: Each phase, neutral and 3-phase average.

2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase, and L-N 3-phase average.

3) Active Power (kW): Each phase and 3-phase total.

4) Reactive Power (kVAr): Each phase and 3-phase total.

5) Apparent Power (kVA): Each phase and 3-phase total.

6) Power Factor: Each phase and 3-phase total.

b. Energy:

1) Active Energy (kWh): Three-phase total.

c. Demand, Derived from Instantaneous rms Meters:

1) Current: Present and maximum.

2) Active: Present and maximum.

3) Reactive: Present and maximum.

4) Apparent: Present and maximum/

d. Power Quality Measurements:

1) THD: Current and voltage from measurements simultaneously from same cycle, as can be calculated from specified sampling rate.

10. I/O: Two optically isolated digital outputs for KYZ pulsing or control. Output signal characteristics shall be 150 mA at 200V.

a. KYZ Pulse: Generate standard KYZ pulses for user-defined increment of metered active energy as follows:

1) User-defined pulse output, associated with kWh.

2) User-defined pulse output, associated with kVArh.

11. Capacities and Characteristics:

a. Circuit Connections:

1) Voltage: Measurement auto-ranging, 60V ac to 400V ac L-N. Connect directly to low-voltage (600V and less) without using voltage transformers. Meter impedance shall be 2 Megohms L-L or greater.

2) Overload Tolerance: 1500V ac, rms, continuously.

3) Current: Connect to instrument-grade current transformer with metering range of 5 mA to 6A. Overcurrent tolerance of instrument shall be 10A continuous, 50A for 10 seconds once per hour, and 120A for one second per hour.

4) Frequency: 45 to 65 hertz.

5) Time: Input from GPS receiver to synchronize internal clock of instrument and to time-synchronize this instrument with network to deviation of not greater than one ms.

2.11 DIFFERENTIAL GROUND-FAULT PROTECTION

A. Description: Ground-fault protection system for 3-phase, 4-wire switchgear having multiple sources shall be devised by manufacturer to insure that proper main or tie breaker(s) operate properly in normal and emergency conditions. Switchgear shall include additional current transformers, ground-fault relays, interlocks, wiring, and accessories to avoid nuisance tripping of circuit breakers connected to main bus of switchgear. Ensure that following occurs on main bus:

1. A ground fault at location in switchgear shall trip system.
2. Combination of normal current flow and ground-fault current flow shall trip system.
3. Circulating currents through neutral due to multiple grounds and sources external to immediate low-voltage power sources shall not trip system.
4. System shall not trip if there is no ground fault, during normal current flow.
5. System shall not trip due to large single-phase currents.

B. Relays: Comply with IEEE C37.90, with test blocks and plugs.

C. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
3. Install plugs in control wiring at shipping splits.

2.12 MAINTENANCE TOOLS

A. Description: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

B. Include following:

1. Portable test set for testing functions of circuit-breaker, solid-state trip devices without removal from switchgear.
2. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
3. Portable test set for testing functions of circuit-breaker, solid-state trip devices without removal from switchgear.
4. Racking handle to move circuit breaker manually between connected and disconnected positions.

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

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

2.13 IDENTIFICATION

A. Compartment Nameplates: Engraved, melamine plastic, as described in Section 260553 "Identification" for each compartment, mounted with corrosion-resistant screws.

B. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce concise visual presentation of principal switchgear components and connections.

2. Medium: Painted graphics, as selected by Architect.

3. Color: Contrasting with factory-finish background as selected by Architect from manufacturer's full range.

C. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce 3.5-by-5-inch self-adhesive equipment label for each work location included in analysis.

2. Comply with requirements in Section 260553 "Identification." Produce 3.5-by-5-inch self-adhesive equipment label for each work location included in analysis. Labels shall be machine printed, with no field-applied markings.

a. Label shall have orange header with wording, "WARNING, ARC-FLASH HAZARD," and shall include following information taken directly from arc-flash hazard analysis:

1) Location designation.

2) Nominal voltage.

3) Flash protection boundary.

4) Hazard risk category.

5) Incident energy.

6) Working distance.

7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

2.14 SOURCE QUALITY CONTROL

A. Testing: Test and inspect low-voltage switchgear per IEEE C37.20.1. Draw-out circuit breakers need not be tested in assembly if they are tested separately.

1. Dielectric Tests: Perform power-frequency withstand tests to demonstrate ability of insulation system to withstand voltages listed in IEEE C37.20.1. Voltage is to be increased gradually from zero to required test value within 5 to 10 seconds and shall be held at that value for one minute.

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

3. Test effectiveness of grounding of each metal-case instrument transformer frame or case.

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

5. Perform control wiring insulation tests.

6. Verify correct polarity of connections between instrument transformers and meters and relays.

B. Serial communications devices within equipment shall be addressed at factory and tested to verify reliable communications to equipment's Ethernet gateway.

C. Low-voltage switchgear assembly will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in of conduits and grounding systems to verify following:

1. Wiring entries comply with layout requirements.

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

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

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding" have been met. Maximum ground resistance shall be 5 ohms at switchgear location.

E. On delivery of switchgear and before unloading, inspect equipment for damage.

1. Verify that tie rods and chains are undamaged and tight, and that blocking and bracing are tight.

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

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

4. Compare switchgear and accessories received with bill of materials to verify that shipment is complete. Verify that switchgear and accessories comply with manufacturer's written instructions and Shop Drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.

5. Unload switchgear, observing packing label warnings and handling instructions.

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

F. Handling:

1. Handle switchgear, per manufacturer's written instructions; avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.

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

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

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

5. Do not damage structure when handling switchgear.

G. Proceed with installation only after examinations are complete and unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

B. Maintain minimum clearances and workspace at equipment per manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS

A. Ground equipment per Section 260526 "Grounding and Bonding."

B. Terminate grounding and bonding conductors on common equipment grounding terminal on switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.

C. Complete switchgear grounding and surge-protector connections before making other electrical connections.

3.4 IDENTIFICATION

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification."

B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Comply with provisions of NFPA 70B, "Testing and Test Methods" Chapter and of NETA ATS.

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

3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

4. Visual and Mechanical Inspection:

a. Verify that circuit-breaker sizes and types correspond to Drawings and coordination study.

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

c. Inspect bolted electrical connections for high resistance using one of following 2 methods:

1) Use 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 lowest value.

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

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

e. Inspect insulators for evidence of physical damage or contaminated surfaces.

f. Verify correct barrier and shutter installation and operation.

g. Exercise active components.

h. Inspect mechanical indicating devices for correct operation.

i. Verify that filters are in place and that vents are clear.

j. Perform visual and mechanical inspection of instrument transformers per "Instrument Transformer Field Tests" Paragraph.

k. Inspect control power transformers.

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

2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.

3) Verify correct functioning of draw-out disconnecting and grounding contacts and interlocks.

5. Electrical Tests:

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

   1) Insulation-resistance values of bus insulation shall be per manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.1.

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

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

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

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

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

d. Control Power Transformers:

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

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

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

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

e. Voltage Transformers:

   1) Perform secondary wiring integrity test. Verify correct potential at devices.

   2) Verify secondary voltages by energizing primary winding with system voltage.

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

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

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

g. Perform system function tests per "System Function Tests" Article.

h. Verify operation of space heaters.

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

C. Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect anchorage, alignment, and grounding.

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

d. Verify unit is clean.

e. Verify that arc chutes are intact.

f. Inspect moving and stationary contacts for condition and alignment.

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

h. Perform mechanical operator and contact alignment tests on both breaker and its operating mechanism per manufacturer's published data.

i. Verify cell fit and element alignment.

j. Verify racking mechanism operation.

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

l. Perform adjustments for final protective-device settings per coordination study provided by Owner.

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

2. Electrical Tests:

a. 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 per manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values shall be per manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than Table 100.1 or manufacturer's written instructions shall be investigated.

b. Measure contact resistance across each power contact of circuit breaker. Microhm or dc millivolt drop values shall not exceed high levels of normal range as indicated in manufacturer's published data. In absence of manufacturer's published data,

investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

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

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

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

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

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

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

i. 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 trip logs and indicators. Auxiliary features shall operate per manufacturer's published data.

j. Verify operation of charging mechanism. Charging mechanism shall operate per manufacturer's published data.

D. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.

b. Inspect physical and mechanical condition.

c. Verify correct connection of transformers with system requirements.

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

e. Verify that unit is clean.

f. Inspect bolted electrical connections for high resistance using one of following 2 methods:

1) Use 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 lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method per manufacturer's published data or NETA ATS,

Table 100.12. Bolt-torque levels shall be per manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

g. Verify that required grounding and shorting connections provide contact.

h. Verify correct operation of transformer withdrawal mechanism and grounding operation.

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

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

2. Electrical Tests of Current Transformers:

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

b. Perform polarity test of each current transformer per IEEE C57.13.1. Polarity results shall agree with transformer markings.

c. Perform excitation test on transformers used for relaying applications per IEEE C57.13.1. Excitation results shall match curve supplied by manufacturer or be per IEEE C57.13.1.

d. Measure current circuit burdens at transformer terminals per IEEE C57.13.1. Measured burdens shall be compared to, and shall match, instrument transformer ratings.

e. Perform insulation-resistance tests on primary winding with secondary grounded. Test voltages shall be per NETA ATS, Table 100.5.

f. Perform dielectric withstand tests on primary winding with secondary grounded. Test voltages shall be per NETA ATS, Table 100.9.

g. Perform power-factor or dissipation-factor tests per test equipment manufacturer's published data.

h. Verify that current transformer secondary circuits are grounded and have only one grounding point per IEEE C57.13.3. That grounding point should be located as specified by Engineer in Project Drawings.

3. Electrical Tests of Voltage Transformers:

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

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

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

d. Perform dielectric withstand test on primary windings with secondary windings connected to ground. Dielectric voltage shall be per NETA ATS, Table 100.9. Test

voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric withstand test, primary windings are considered to have passed test.

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

f. Verify that voltage transformer secondary circuits are grounded and have only one grounding point per IEEE C57.13.3. Test results shall indicate that circuits are grounded at only one point.

E. Ground-Resistance Test:

1. Visual and Mechanical Inspection:

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

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

c. Inspect bolted electrical connections for high resistance using one of following 2 methods:

1) Use 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 lowest value.

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

d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test per IEEE 81 on main grounding electrode or system. Resistance between main grounding electrode and ground shall be no more than 5 ohms.

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

c. Inspect physical and mechanical condition.

d. Inspect bolted electrical connections for high resistance using one of following 2 methods:

1) Use 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 lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method per manufacturer's published data or NETA ATS,

Table 100.12. Bolt-torque levels shall be per manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

F. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect bolted electrical connections for high resistance using one of following 2 methods:

1) Use 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 lowest value.

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

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

d. Verify that unit is clean.

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

2. Electrical Tests:

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

b. Calibrate meters per manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.

c. Verify instrument multipliers. Instrument multipliers shall be per system design specifications.

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

G. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

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

b. Verify operation of LEDs, display, and targets.

c. Record passwords for each access level.

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

e. Check tightness of connections.

f. Verify that frame is grounded per manufacturer's written instructions.

g. Set relay per results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."

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

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to grounded frame per manufacturer's published data.

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

c. Check functional operation of each element used in protection scheme as follows:

1) ANSI No. 2/62, Timing Relay:
   a) Determine time delay.
   b) Verify operation of instantaneous contacts.

2) ANSI No. 24, Volts/Hertz Relay:
   a) Determine pickup frequency at rated voltage.
   b) Determine pickup frequency at second voltage level.
   c) Determine time delay.

3) ANSI No. 25, Sync Check Relay:
   a) Determine closing zone at rated voltage.
   b) Determine maximum voltage differential that permits closing at zero degrees.
   c) Determine set points of live line, live bus, dead-line, and dead bus.
   d) Determine time delay.
   e) Verify control functions of dead bus/live line, dead-line/live bus, and dead bus/dead-line.

4) ANSI No. 27, Undervoltage Relay:
   a) Determine dropout voltage.
   b) Determine time delay.
   c) Determine time delay at second point on timing curve for inverse time relays.

5) ANSI No. 32, Directional Power Relay:
   a) Determine minimum pickup at maximum torque angle.
   b) Determine closing zone.
   c) Determine maximum torque angle.
   d) Determine time delay.
   e) Verify time delay at second point on timing curve for inverse time relays.

6) ANSI No. 46, Current Balance Relay:
   a) Determine pickup of each unit.
   b) Determine percent slope.
   c) Determine time delay.

7) ANSI No. 46N, Negative Sequence Current Relay:
   a) Determine negative sequence alarm level.
   b) Determine negative sequence minimum trip level.
   c) Determine maximum time delay.
   d) Verify 2 points on I-2-squared-T curve.

8) ANSI No. 47, Phase Sequence or Phase Balance Voltage Relay:
   a) Determine positive sequence voltage to close NO contact.

b) Determine positive sequence voltage to open NC contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close NO contact with sudden application of 120 percent of pickup.
e) Determine time delay to close NC contact on removal of voltage when previously set to rated system voltage.

9) ANSI No. 50, Instantaneous Overcurrent Relay:
a) Determine pickup.
b) Determine dropout.

10) ANSI No. 51, Time Overcurrent:
a) Determine minimum pickup.
b) Determine time delay at 2 points on time current curve.

11) ANSI No. 64, Ground Detector Relay:
a) Determine maximum impedance to ground causing relay pickup.

12) ANSI No. 67, Directional Overcurrent Relay:
a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Plot operating characteristics.
d) Determine overcurrent unit pickup.
e) Determine overcurrent unit time delay at 2 points on time current curve.

13) ANSI No. 87, Differential Relay:
a) Determine operating unit pickup.
b) Determine operation of each restraint unit.
c) Determine slope.
d) Determine harmonic restraint.
e) Determine instantaneous pickup.

d. Control Verification:

1) Functional Tests:
a) Check operation of active digital inputs.
b) Check output contacts or SCRs, preferably by operating controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) On completion of testing, reset minimum/maximum recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

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

H. Ground-Fault Protection Field Tests: Evaluate interconnected system per switchgear manufacturer's written instructions.

1. Determine proper location of sensors around bus of circuit to be protected. This determination may be done visually, with knowledge of which bus is involved.

2. Verify grounding points of system to determine that ground paths do not exist that would bypass sensors. Use high-voltage testers and resistance bridges.

3. Test installed system for correct response by application of full-scale current into equipment to duplicate ground-fault condition, or by equivalent means such as by simulated fault current generated by following:

   a. A coil around sensors.

   b. A separate test winding in sensors.

4. Record test results on test form provided with instructions provided by manufacturer.

I. Switchgear components will be considered defective if they do not pass tests and inspections.

J. Remove and replace defective units and retest.

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

3.6 SYSTEM FUNCTION TESTS

A. System function tests shall prove correct interaction of sensing, processing, and action devices. Perform system function tests after field quality-control tests have been completed and components have passed specified tests.

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

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

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

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

C. Prepare test and inspection reports.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than 6 months after Final Acceptance, and if requested by Owner, perform following voltage monitoring:

1. During period of normal load cycles as evaluated by Owner, perform 7 days of 3-phase voltage recording at outgoing section of each piece of switchgear. Use voltmeters with calibration traceable to NIST standards and with chart speed of not less than one inch per hour. Voltage imbalance greater than one percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.

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

   a. Adjust switchgear taps.

   b. Prepare written request for voltage adjustment by electric utility.

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

4. Report: Prepare written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove covers before inspection.

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

2. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of one degree C at 30 degrees C.

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

a. Description of equipment to be tested.

b. Discrepancies.

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

d. Probable cause of temperature difference.

e. Areas inspected. Identify inaccessible and unobservable areas and equipment.

f. Identify load conditions at time of inspection.

g. Provide photographs and thermograms of deficient area.

4. Act on inspection results per recommendations in NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

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

3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for 2 years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within 2 years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION