SECTION 261116 - SECONDARY UNIT SUBSTATIONS

Latest Update: 08.09.2024 See Underlined Text

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off all "Underlines",)

PART 1 - GENERAL

1.1 RELATED DOCOMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

1.2 DESCRIPTION OF WORK

A. This section provides the specification for the Secondary Unit Substations and related accessories that shall be furnished by the manufacturer.

B. The supplier's shipping company shall verify all height, weight, and traffic limitations when considering pricing and actual delivery. The delivery at the site for the equipment unloading shall be scheduled for normal working hours of Monday through Friday (7:00am – 3:00pm). The actual delivery through the University of Maryland, Baltimore campus must be scheduled with the University to prevent travel through major campus activity days. The shipper shall consider that it may take up to 4 hours before the secondary unit substation is lifted off the delivery truck and the truck is free to leave.

1.3 SUMMARY

A. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:

1. Primary incoming section.
2. Transformer.
3. Secondary distribution section.

1.4 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.5 SUBMITTALS

A. Compliance Statement as described under the quality assurance section of this specification.

B. Product Data: Include rated capacities, furnished specialties, and accessories.

C. 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.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features including working clearances, conduit entry points, and base mounting points.
3. One-line diagram.
4. List of materials.
5. Nameplate legends.
6. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
7. Short-time and short-circuit current ratings of secondary unit substations and components.
8. Ratings of individual protective devices.
9. Transformer section submittals including:
    a. Dimensioned plan and elevations with tap, control power transformer, fan and temperature monitor locations, and phase, neutral and ground connection locations.
    b. Enclosure details, including removable panel descriptions, louver locations, control wiring routing, sheet metal gauge, and painting details.
    c. Terminal locations and details for phase, neutral and ground connections.
    d. Coil conductor materials and construction.
    e. Insulation materials.
    f. Test data sheets for similar transformers with test data on load losses, no-load losses and sound level.
    g. Temperature control system description, including details on the control power transformer, fans, temperature monitor, alarms and hinged panel for the monitor.
    h. Schematic and connection diagrams for the temperature control system.
    i. Full size copy of the nameplate.
    j. Coil-to-bus/line connection materials, support and details.
    k. Bus bar and line termination connection and support details.
    l. ANSI Damage curve for secondary unit substation transformers.
    m. Detailed location, mounting and wiring of the lightning arrestors.
10. Secondary voltage distribution section submittals containing:
    a. Dimensioned plan and elevations with circuit breaker, current sensor and metering device locations, and phase, neutral and ground bus terminal locations.

b. One line diagram with bus, circuit breaker, trip unit, and fuse quantities and ratings, and interlock provisions.
c. Compartment details including front door and rear panel descriptions, sheet metal gauge, painting details, mimic bus details, and breaker lifting device description.
d. Terminal locations and details for phase, neutral and ground connections.
e. Phase-to-phase clearances and phase-to-ground clearances.
f. Bus bar connection and support details and bus materials.
g. Insulator and barrier details and materials.
h. Circuit breaker, trip unit, and current sensor descriptions.
i. Trip unit time-current characteristic curves.
j. Detailed circuit breaker controls, schematic and connection diagrams, and sequences of operation including terminal point numbers and locations.
k. Secondary metering description, including details on the current transformers, potential transformers, ammeters, voltmeters, and meter switches.
l. Schematic and connection diagrams for the PLC system including terminal point numbers and locations.
m. DC Connection schematics including terminal point numbers and locations.
n. Nameplate engraving.
o. Time-current curves, including selectable ranges for each type of overcurrent protective device.
p. Mimic-bus diagram.

11. Sequence of Operations.

D. Coordination Drawings: 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:

1. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and ground rod locations.
2. Location of structural supports for structure-supported raceways and busways.
3. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

E. Product Certificates: For secondary unit substations, signed by product manufacturer.

F. Qualification Data: For independent testing agency.

G. Material Test Reports: For secondary unit substations.

H. Factory test reports.

I. Field quality-control test reports.

J. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

K. Electronic copy of as-left relay settings and PLC program on USB drive.

1.6 QUALITY ASSURANCE

A. Compliance Statement: The equipment manufacturer shall include a Compliance Statement, at the time of Bid, listing each Specification Section, and Part 1, 2, and 3 Sub-Sections, stating, paragraph-by-paragraph, compliance with the Specification, each minor nonconformity that is within the intent of the Specification, and proposed nonconformities. Provide short description of minor nonconformities, and detailed explanation of other nonconformities.

B. Independent Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of secondary unit substations and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

E. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2.

G. Comply with IEEE C37.121.

H. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. 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.

D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

E. Unit Substations are to arrive on site in a phased manner to be established with the electrical contractor and the project schedule. Equipment Manufacturer may manufacturer the switchgear prior to the scheduled delivery date and is responsible for storage prior to the agreed delivery dates.

F. The Electrical Contractor may attempt to coordinate delivery of equipment such that equipment may be set in place on the same day it is delivered on site. If this is not possible, the Electrical Contractor will arrange for offloading at a staging area and will arrange and pay for subsequent transfer to the site, when equipment can be set in place.

1.8 PROJECT CONDITIONS

A. Field Measurements: Indicate measurements on Shop Drawings.

B. Interruption of Existing electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify UMB no fewer than ten (10) days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without UMB's written permission.
3. Indicate method of providing temporary electrical service.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. The Equipment Manufacturer shall fabricate the equipment to within indicated maximum dimensions with clearances to accommodate access for maintenance and operation.

D. The electrical contractor shall include in his price the cost of all premium time required for outages and other work which interferes with the normal use of the building, which will be performed, in most cases, during other than normal work time and at the convenience of the University.

E. The operation of electrical panels or power switches; required to achieve an outage must be accomplished by University personal only. Unauthorized of electrical panels, power switches by contractors personnel will result in extremely serious consequences for which the contractor will be held accountable.

1.9 COORDINATION

A. Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 EXTRA MATERIALS

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

1. Spare Indicating Lights: Six of each type installed.
2. Touchup Paint: One half-pint container of paint matching enclosure's exterior finish.
3. Primary Switch Contact Lubricant: One container.
4. One set of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure relief device.
5. Fuses: Two of each type.
6. Provide remote racking devices and accessories.

1.11 WARRANTY/GUARANTEE

A. The manufacturer shall warrant the components and equipment installed, as per the specification, to be free from defects in materials or workmanship for a period of not less than 24 months, to begin upon manufacturer completion of the system startup.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Philadelphia Electrical Equipment Company (PEECO)
2. Eaton
3. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Separate secondary distribution equipment connected with busway.

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

2.3 MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION

A. Metal-enclosed, air-interrupter switchgear, with fuses, complying with IEEE C37.20.3.

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

1. System Voltage: 13.2 kV nominal; 15 kV maximum.
2. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
3. Main-Bus Rating: 1200 A, continuous.

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

1. Rating: 600 A continuous duty and load break.
2. Two-Time Duty-Cycle Fault Closing: 40 000 A, asymmetrical.
3. Switch Action: No external arc and no significant quantities of ionized gas released into enclosure.
4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism. Compact construction medium voltage switches are not acceptable.
5. 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.
6. Protective Shields: Cover live components and terminals.
    a. Fuse Mounts: Single frame mounted and de-energized when switch is open.
7. Mechanical Interlock: Prevent opening of switch compartment door unless switchblades are open, and prevent closing switch if door is open.
8. Window: Permits viewing switchblade positions when door is closed.

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

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

1. 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.
2. Indicator integral with each fuse to show when it has blown.
3. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

E. 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.

2.4 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.51, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.

B. Enclosure: Indoor, ventilated, vacuum-pressure encapsulated (VPE), VPI type or Cast Coil type, with insulation system rated at 185^0C with an 80^0C average winding temperature rise above a maximum ambient temperature of 40^0 C.

C. Cooling System: Class AFA, air cooled with forced-air rating complying with IEEE C57.12.01.
1. 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.
2. The temperature controller shall be mounted flush on the front of the transformer, 54 inches above finished floor.
3. The temperature monitor shall be mounted on a hinged front plate of a flush mounted box. The electrical connection shall be accessible and the monitor shall be removable without de-energizing the transformer.
4. The wiring for the temperature monitor shall be routed and supported independently of the transformer enclosure so that the enclosure panels can be removed without affecting the wiring. All wiring shall comply with the requirements of the Control Wiring section of this specification.
5. The transformer temperature monitor and automatic cooling fan controller shall be internally powered from a control power transformer.

6. The temperature monitor shall include an LED or LCD display to allow reading of the hot spot temperature in each phase, and the highest temperature seen on each phase since the last reset. Additional features as listed below:
7. A reset button shall be provided to reset the maximum readings.
8. Indication Lights:
9. Green – Power On
10. Amber – Fan On
11. Red – High Temperature
12. Alarm Silence Pushbutton
13. Auto/Manual Fan Control Switch
14. System Test Switch

D. Insulation Materials: IEEE C57.12.01, rated 220^0C.

E. Insulation Temperature Rise: 80^0C, maximum rise above 40^0C.

F. Basic Impulse Level: 95 kV.

G. Voltage Ratings:

1. Primary System Voltage: 13.2 kV, 3 phase delta connected.
2. Secondary System Voltage: 480/277 V, 3 phase wye connected.

H. Full-Capacity Voltage Taps: four (4) nominal 2.5% taps, two (2) above and two (2) below rated primary voltage.

I. Sound level may not exceed 64dBA level, without fans operating.

J. Impedance: 5.75 %.

K. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm. Provide Square D Model 98 transformer temperature monitor for remote recording of transformer winding temperatures.

L. Core and Coil Assemblies: Transformer coils shall be copper continuously wound on a non-aging, cold-rolled, grain-oriented, high permeability silicon metal core of electrical grade steel with insulated laminations. Aluminum windings are not acceptable.

M. Core and coil assembly shall be mounted on a structural steel base, which shall be isolated from the rest of the structure by vibration pads.

N. The electrical insulation system shall utilize Class H material in a fully rated 220^0 C system. Transformer design temperature rise shall be based on a 30^0 C average ambient over a twenty four (24) hour period with a maximum of 40^0 C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester or Nomex. All insulating materials must be rated for continuous 220^0 C duty. The

insulation between the high and low voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.

O. High-voltage and low-voltage windings shall be copper. The high voltage winding shall be wound over the low voltage winding with sufficient mechanical bracing to prevent movement during fault conditions and sufficient solid insulation to isolate the high voltage winding dielectric potential from the low voltage windings.

P. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

2.5 SECONDARY DISTRIBUTION SWITCHGEAR

A. The secondary distribution section shall be draw out, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.
   1. Section barriers between all circuit-breaker compartments shall be extended to rear of section.

B. Ratings:

   1. System Voltage: 480/277 V
   2. Symmetrical Short Circuit Rating: As indicated on drawings.
   3. Main-Bus Rating: As indicated on drawings.

C. Switchgear Structure:
   1. Match and align the front and back of the switchgear.
   2. Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.
   3. Allow the following circuit-breaker functions to be performed when the compartment door is closed:

      a. Operate manual charging system.
      b. Open and close the circuit breaker.
      c. Examine and adjust the trip unit.
      d. Read the breaker nameplate.

   4. Locate instrumentation transformers within the breaker cell and make front accessible and removable.
   5. The sections shall be constructed of steel frames and heavy gauge steel panels sized to maintain required alignments and clearances at all times. The sections shall also be sufficiently rigid to restrict deformation from external forces and weights that may be applied during maintenance activities.
   6. The sections shall be capable of withstanding the lifting, skidding, jacking and/or rolling (in any direction) actions needed to install the equipment. Factory installed lifting eyes shall be provided on each section.

7. The sections shall have provisions for anchoring to channel embeds in the housekeeping pad.
8. Section barriers between all circuit-breaker compartments shall be extended to rear of section.
9. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
10. Circuit-breaker compartments shall be equipped to house draw out-type circuit breakers and shall be fitted with hinged outer doors.
11. Fabricate enclosure with removable, hinged rear cover panels, to allow access to rear interior of switchgear.

D. Switchgear Bus:
1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
4. Phase-Bus Material: Hard-drawn copper of 98% minimum conductivity, with copper feeder circuit-breaker line connections.
5. Use copper for connecting circuit-breaker line to copper bus.
6. Contact Surfaces of Buses: Silver plated.
7. Feeder Circuit-Breaker Load Terminals: Insulated silver-plated copper bus extensions equipped with bolted connectors for outgoing circuit conductors. Provide cable lugs sized as indicated on the drawings.
8. Ground Bus: Hard-drawn copper of 98% minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm).
9. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
10. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, spray-applied, flame-retardant insulation.

    a. Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
    b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

11. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
12. The vertical bus shall be held rigid in a support structure of non-hygroscopic and flame retardant molded glass reinforced polyester.
13. Vertical and horizontal busbars shall be isolated from the cable compartment by steel barriers. No live busbars shall be accessible from the rear cable compartments except the circuit breaker load side terminations.
14. Cable feeder compartments shall have sufficient space for all cables entering from above and shall be easily accessible from the rear. Cable tie points shall be provided

on the sides of such sections. No cable tie bars shall block access to the rear of the switchgear.

E. Special Provisions to Accommodate Switchgear Maintenance:
   1. Barriers covering the bus sub-assembly in each section of gear shall be designed for ease of removal to accommodate maintenance.
   2. Where carriage bolt assemblies are installed at bus connections, the bolts shall face the rear of the switchgear to facilitate access for maintenance.
   3. The switchgear shall be arranged to allow thermal and ultrasonic scans with the bus energized and under load.

      a. Provide two (2) combined visual, Ultraviolet (UV), and Infrared (IR), rectangular
      b. viewing windows in the rear cover of each switchgear section. Center each window at 1/3 points along the height of the section and centered horizontally on the section so that all cable terminations can be scanned through the windows.
      c. Provide one (1) round ultrasonic scan window in the front door of each breaker compartment. Locate the window so that a scan can be made of the arc chutes and contacts of the breaker.

   4. Provide design details to the University's Representative prior to manufacturer to confirm compliance with the above provisions.
   5. Low voltage auxiliary equipment including meters, relays, and PLC’s shall be located in separate compartments that include shorting blocks for current transformers and terminal strips with disconnecting means for voltage transformers. The low voltage auxiliary equipment shall be able to be taken out of service locally within this separate section, and there shall be no power cabling, bussing, or circuit breakers within the section.

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

      a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
      b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

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.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.
4. Each compartment shall be dead-front. Shutters shall close automatically as a breaker is racked out of the “connected” position. Control contacts shall be “made” when the breaker is in the “test” or “connected” position.
5. A guide rail system shall be used to ensure accurate alignment of the breaker primary and secondary disconnects during draw out operation.
6. Positive mechanical interlocks shall prevent the circuit breaker from being racked in or out unless the circuit breaker is open and shall prevent the circuit breaker from being closed while it is being racked in or out. The circuit breaker shall not be permitted to close except in the “connected” and “test” positions.
7. Each circuit breaker cubicle shall contain a positive rejection mechanism so that only the circuit breaker frame for which the cubicle was designed can be inserted.
8. Anti-pumping mechanism shall be provided.
9. Compartment doors shall have padlocking hasps. All front compartment doors shall be hinged and lockable.
10. Circuit breakers shall be capable of being padlocked in the drawn-out position.
11. Main, Tie, and Feeder Circuit Breaker Compartments: Shutters shall be supplied to cover circuit breaker primary line and load disconnects when the circuit breaker carriage is removed from its compartment.

G. Circuit Breakers:
1. Circuit breakers shall be individually mounted, draw out, 600 volt (nominal) power circuit breakers in compliance with ANSI C37.13, C37.16, C37.17, C37.50, NRTL-listed and labeled to UL-1066.
2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker as indicated on the drawings; voltage and frequency ratings same as switchgear.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

a. Normal Closing Speed: Independent of both control and operator.
b. Slow Closing Speed: Optional with operator for inspection and adjustment.
c. Stored-Energy Mechanism: Electrically charged, and .the operator's choice of manual charging.

1) Operating Handle: One for each circuit breaker capable of manual operation.
2) Electric Close Button: One for each electrically operated circuit breaker. This control switch shall be a Series 31-B knob.
3) All open and close buttons on the circuit breakers shall be equipped with a protective cover to prevent inadvertent operation.

d. Operation counter.

4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one (1) or two (2) current transformers or sensors per phase, a release mechanism, and the following features:

a. Provide trip devices which are interchangeable between compatible breaker frames. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. The rating plug shall be interlocked with the tripping mechanism to automatically "open" the breaker when the plug is removed. The breaker shall remain "trip free" with the plug removed. In addition, rating plugs shall be keyed to prevent incorrect application between different frame ratings.
b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
c. Temperature compensation that ensures accuracy and calibration stability from minus 5^0 C to plus 40^0 C. Circuit breakers shall have short circuit current withstands and interrupting ratings that meet or exceed 65kA symmetrical fault current.
d. Field-adjustable, time-current characteristics.
e. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
f. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
g. Pickup Points:

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

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

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

2) Arrange to provide protection for four-wire circuit or system.
3) Arrange to provide protection for four-wire, double-ended substation.

5. All trip units shall be provided with zone selective interlocking schemes. A fully functional zone selective interlocking scheme shall be provided for all main, tie, and feeder breakers in the switchgear.
6. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
7. Auxiliary Contacts:

   a. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
   b. Spare auxiliary switches, at least two, unless other quantity is indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

8. 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.
9. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of draw out mechanism.
10. Circuit breakers shall contain a true two-step, stored energy mechanism providing quick-make, quick-break operation capable of charging-after-close operation. It shall be possible to discharge the closing springs without closing the main contacts. Maximum closing time shall be five (5) cycles at nominal control voltage.
11. The tie breaker shall be identical to the main breakers and shall be capable of being exchanged with either main breaker.
12. A factory-installed "OFF" button padlock provision shall be included to prevent charging of the breaker mechanism when it is engaged.
13. Movement of the breaker handle alone shall not cause the breaker to change state (open or close).
14. Network Communications: Data and digital data-transmission interface must be provided for all electronic trip units. Power-type trip units shall be provided. Provide control wiring to daisy-chain connections for all feeder and main breakers on each switchgear bus to a common gateway, for a total of two gateways per double-ended substation. The gateway shall have a single ethernet TCP/IP communication interface for external communication connection to the University metering system. Communicate the following network relay parameters:
    a. Current in each phase.
    b. Phase-to-phase and phase-to-neutral voltages.
    c. Three-phase kW, kVA and kVAR.
    d. Frequency.
    e. Power factor.
    f. Breaker status.

g. Breaker raking.
h. kWH.

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

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

J. Sync Check Relays: Provide sync check relays on Main and Tie breakers to allow closing of breakers when both sides of breakers are synchronized or when closing into a dead bus. Sync check relays will also allow for closed transition transfer of sources.

K. Breaker Time-out: Provide a timer (factory set to ten (10) seconds, adjustable) that opens the tie breaker if both main breakers and the tie breaker are closed for an extended period of time.

L. Control Power:
1. Provided from integral control power transformers.
2. All main, tie, and feeder circuit breakers shall be provided with all hardware required for remote tripping and closing from the PLC control system.
3. Manual spring charging operators and close and trip pushbuttons shall be accessible from the front of the circuit breaker when it is installed in a cubicle, with the cubicle door closed.
4. The following circuit breaker operating status mechanical indicators at the front door of each circuit breaker compartment:

   a. Closing spring status (charged/discharged).
   b. Circuit breaker main contact status (open/closed).
   c. Circuit breaker draw out position (connect/test/disconnect).

5. Standard padlocking provisions, on the front of the circuit breaker, to lock the circuit breaker open and mechanically trip-free. The padlock provision shall accept up to three padlocks with 1/4 inch to 3/8 inch diameter shank.
6. Provide circuit breaker mechanism operated contacts (MOC) and truck operated contacts (TOC) as required for implementation of the specified control logic.
7. Provide two spare sets of contacts that open when the circuit breaker is open and close when the circuit breaker closes (52a), and two spare sets of contacts that close when the circuit breaker is open and open when the circuit breaker closes (52b), wired through secondary disconnect devices to a terminal block in the stationary housing. Provide an auxiliary relay to provide additional “52a” and “52b” contacts for each breaker. Provide the maximum number of contacts allowable for each type.
8. Circuit breakers shall be equipped with wheels that allow the circuit breaker to be rolled into the cubicle once it is installed on the draw out rails.

M. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage and adjustable time delay, as required by the automatic transfer scheme. Undervoltage relays shall not be provided on feeder circuit breakers.

N. 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. All indicating lights shall be LED type with push-to-test feature.
1. Red – Closed
2. Green – Open
3. Amber/Blue/White – General Indication as required for interlocking.

2.6 LOW VOLTAGE INSTRUMENT SECTION

A. Instrument Transformers: Comply with IEEE C57.13.
1. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y shall be provided on the bus side of the main breaker.
2. Protection Current Transformers: Integral to circuit breaker rating plug assembly. Rating plugs shall be removable for increasing/decreasing trip unit rating without removing or replacing the trip unit itself.

B. Control Wiring: Factory installed type SIS rated 600 volt, 90^0 C, furnished with wire markers at each termination except where installation environments (temperature and chemical) require specialized insulation systems. Wires shall terminate on terminal blocks with marker strips numbered in agreement with detailed connection diagrams complete with bundling, lacing, and protection. Complying with the following:
1. Flexible stranded conductors for No. 12 AWG and larger.
2. Minimum size of #14 AWG for 120VAC circuits, minimum size of #12 AWG for 125VDC circuits.
3. All current transformer circuits shall be #10 AWG and wired through shorting type terminal blocks.
4. All control wiring shall be 600V SIS. The use of nylon or PVC jackets is not acceptable.
5. Each control wire shall be uniquely numbered at each end and at each termination point.
6. No more than two wires shall be connected at a single wiring terminal. Thread on wire nuts or split bolt connectors are not permitted. In-line control wire splices are not acceptable.
7. Terminal block shall be provided for all conductors requiring connection to circuits external to the specified equipment, where internal circuits cross shipping splits, and where equipment part replacement and maintenance will be facilitated.
8. Leave slack in bundled conductors at hinges and interconnections between shipping units. Wiring traversing hinges or other forms of flexible constructions shall be high stranded and shall traverse the area of bending normal to the plane of rotation so as to impart a twisting rather than a bending motion to the cable or wire bundle.

9. Short circuiting type terminal blocks shall be provided for shorting and grounding all CT leads. Non-short circuiting type terminal blocks shall be provided for terminating all control and protection leads.
10. All control wiring shall be routed through the low voltage compartments and secured using tie wraps.

C. Customer Metering Compartment: A separate isolated customer metering compartment to facilitate service while the switchgear is energized and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

D. Control Power Supply:

1. Control power transformer must supply 120 V(ac) control circuits from line side of main breakers source through secondary disconnect devices.
2. Dry-type transformers must be in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
3. Two control power transformers in separate compartments with necessary interlocking relays; transformer must be connected to line side of associated main circuit breaker.
   a. Secondary windings must be connected through internal automatic transfer switch to paralleling switchgear control power bus.

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

2.7 DIGITAL METERING

A. Provide a dedicated meter on main of each switchboard, Refer to Specification Section 260913 for metering requirements.

2.8 ACCESSORIES

A. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions. (Total of four (4) per unit substation)
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

4. 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.
5. Remote Racking Device: Remote racking device capable of remotely inserting or removing the draw out circuit breakers while the operator is away from the switchgear. Device should operate off 120V receptacle.

B. Combination visual, UV, and IR scan windows shall be rectangular having an overall outside dimension of 12”W x 8.1”H with a window dimension of 9.3”W x 5”H. Window housing shall be aluminum with a locking cover and 316 stainless steel hardware. Optical material shall be a UL 746 compliant visual, UV, and IR transmissive polymer. Window shall be rated IP65/NEMA 4. Window shall be IRISS CAP-CT-12.

C. Ultrasound ports shall be round with a body diameter of 2.6” with a port diameter of 0.5”. Ports shall be made of UL 94 5VA nylon with a stainless steel cover. Ports shall be rated IP65/NEMA 4 when closed. Ports shall be IRISS VP-12-US.

2.9 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagrams, and emergency procedures. Fabricate the frame of finished wood or metal and cover instructions with clear acrylic plastic. Mounted of front of secondary unit substation. A laminated copy of the switchgear sequence of operations shall be provided including instructions on how to operate the switchgear.

C. Frame updated new single line diagram that incorporates all new equipment and connections provided under this project. Print at full drawing size. Fabricate the frame of finished wood or metal and cover instructions with clear acrylic plastic. Coordinate mounting location in electrical room with the University.

D. Mimic Bus: Continuous mimic bus, arranged in single line diagram format, using symbols and lettered designations consistent with approval mimic-bus diagram. Provide on both medium and low voltage switchgear sections as well as on the power transformer.
1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual representation of principal switchgear components and connections.
2. Medium: Painted graphics, as selected by the Engineer.
3. Color: Black for low voltage switchgear sections. Red for medium voltage switchgear sections and transformer.

2.10 SUBSTATION CONTROL SYSTEM

A. A PLC-based control system shall be provided including all associated power supplies, I/O, network cards, and HMI's (Human Machine Interface) required to provide a fully functional system. The PLC system shall be Allen Bradley based unless an alternate is approved by the University.

B. A control power UPS integral to the switchgear and sized by the manufacturer shall be provided to power the control system components including the HMI, PLC's, power supplies, and I/O modules. The UPS shall be provided A/C power from the integral substation control power transformers.

C. The substation automation interface shall be via a touchscreen with the following characteristics:
   1. Color, minimum twelve (12) inch diagonal TFT LCD display capable of displaying both text and graphics.
   2. The display shall support a minimum resolution of 1280x1024 pixels, 16 million displayable colors 24-60kHz horizontal scan rate, 56-75kHz refresh rate.
   3. The touchscreen shall be clear glass with light transmission of 95% or better furnished with a Surface Acoustic Wavetouch interface.

D. HMI Screen Listing
   1. The switchgear automation shall provide the following screens. The screens shall provide all of the information, metering, control, annunciations settings and indications listed below:
   2. Main Menu Screen with a complete listing of major screens.
   3. System Overview Screen with animated graphic display of the electrical one line.
   4. Electrical one-line screens for the medium voltage switches, transformer, and low voltage switchgear.
   5. System Control Screen
   6. System Metering Screen.
   7. System Settings Screen.
   8. Utility control screen.
   9. Utility metering screen
   10. Utility setting screen.
   11. Password entry screen that shall contain a numeric keypad for password entry.
   12. Alarm summary screen that shall contain a time/date stamped system alarm summary. Alarm log shall be exportable to external media.
      a. System annunciation screen that shall contain status, lamp test and alarm points.
      b. Utility annunciation screen that shall contain status, lamp test and alarm points.
   13. Alarm summary report.

E. Circuit Breaker Control

1. The substation control system shall have the ability to open and close the main, tie, and all feeder breakers in the 480 V switchgear. The manufacturer shall provide all I/O and breaker trip and close mechanisms required for this functionality.

F. Sequence of Operations
   1. General System Requirements
      a. When in AUTO, the control system shall automatically switch the main and tie breakers in the 480 V switchgear to restore power to the bus upon a loss of utility.
      b. When in MANUAL, the system shall be able to be manually operated and indefinitely paralleled by the Operator. There shall be no kirk key interlocks between the main and tie circuit breakers.
      c. Return to normal power configuration after an outage shall be a manually initiated automatic operation, meaning the Operator must physically intervene (i.e. button press or switch actuation) to begin the automated breaker sequence to return to normal operating conditions. There shall be no Retransfer Mode operator switch.
      d. All key control functions, including but not limited to, auto/manual selection, main and tie breaker operation, breaker LED indicator lights, and closed/open transition switches shall be physical switches. It is acceptable to duplicate functions on the HMI via soft keys.
   2. Key Use Selector Switches:
      a. Auto/Manual (43-AM): Selection between Automatic and Manual mode for the control system.
      b. Maintenance Mode Preferred Source (43-PS): 3 position switch to select between Bus 1, Split Bus, Bus 2.
      c. Maintenance Mode Active: Push button switch that, when pressed and the system is in AUTO, will automatically closed transition switch the main and tie breakers to align the bus per the Maintenane Mode Preferred Source switch.
      d. Open/Closed Transition (43-OC): Selection between open and closed transition.
   3. Normal Operating Mode:
      a. Main breakers M1 and M2 are closed; tie breaker T1 is open.
      b. 43-AM is the AUTO position.
      c. 43-OC is in the CLOSED position.
      d. 43-PS is in the SPLIT position.
   4. Single Utility Source Failure M1 (or M2)
      a. Undervoltage detected on M1 (or M2).
      b. After adjustable source failure timer expires, open breaker M1 (or M2)
      c. Close tie breaker T1,
   5. Return of Failed Utility Source M1 (or M2)
      a. Normal voltage detected by M1 (or M2) voltage relay.
      b. After adjustable source stability timer expires, “Restore to Normal” will illuminate on the HMI as well as via a physical button.

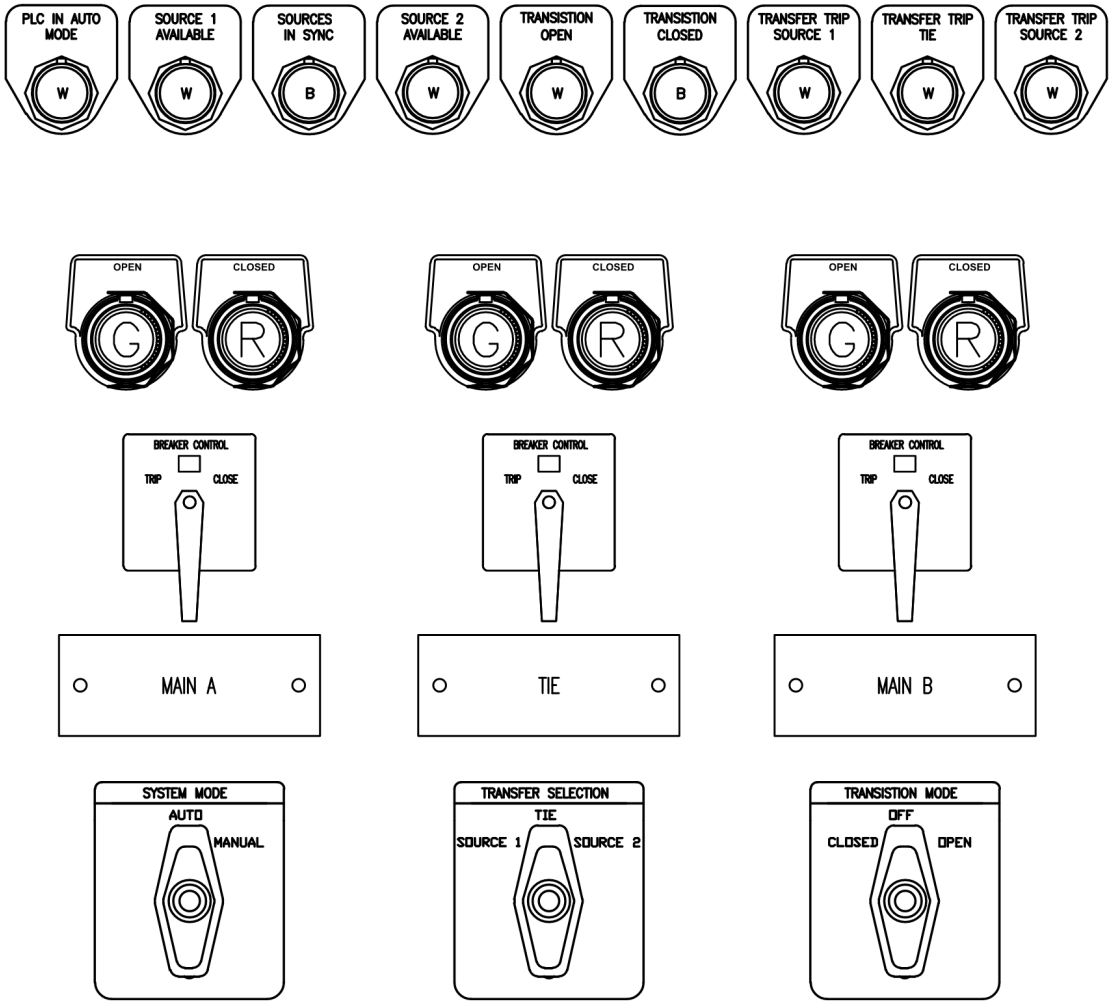
c. The Operator will either manually reconfigure the system to Normal Operating Mode or will manually initiate an automatic return sequence. If the automatic return sequence is initiated, the system will Close breaker M1 (or M2) and open breaker T1 in a closed transition switchover.

6. Dual Utility Source Failure (M1 and M2)
   a. Undervoltage detected simultaneously on M1 and M2 and the adjustable source stability timer expires.
   b. The system will not operate any breakers. Breakers M1 and M2 will remain closed and T1 will remain open.
7. Sequential Utility Source Failure (M1 then M2 or M2 then M1)
   a. Undervoltage detected on M1 (or M2).
   b. After adjustable source failure timer expires, open breaker M1 (or M2)
   c. Close tie breaker T1,
   d. Undervoltage detected on M2 (or M1).
   e. After adjustable source failure timer expires, open breaker M2 (or M1)
   f. The system will not operate any breakers. Breakers M2 (or M1) and T1 will remain closed and breaker M1 (or M2) will remain open.
8. Return of Alternate Utility Source
   a. If, at the end of Sequence 7 above, the source associated with the open breaker returns as detected by the associated main voltage relay and the utility stability timer expires.
   b. The Operator will either manually reconfigure the system to Normal Operating Mode or will manually initiate an automatic return sequence. If the automatic return sequence is initiated, the system will Close breaker M1 (or M2) and open breaker T1.
9. Maintenance Mode – Bus 1 Preferred
   a. Operator places 43-AM into MANUAL mode.
   b. Operator places 43-PS to Bus 1.
   c. Operator places 43-AM into AUTO mode.
   d. Operator presses Maintenance Mode Active button.
   e. The system will close tie breaker T1 and then open breaker M2 in a closed transition transfer.
10. Maintenance Mode – Bus 2 Preferred
   a. Operator places 43-AM into MANUAL mode.
   b. Operator places 43-PS to Bus 2.
   c. Operator places 43-AM into AUTO mode.
   d. Operator presses Maintenance Mode Active button.
   e. The system will close tie breaker T1 and then open breaker M1 in a closed transition transfer.
11. Return to Normal Operating Mode from Maintenane Mode
   a. Operator places 43-AM into MANUAL mode
   b. Operator places 43-PS to SPLIT.
   c. Operator places 43-AM into AUTO mode.
   d. Operator presses Maintenance Mode Active Switch button.

e. The system will close breaker M1 (or M2) and then open tie breaker T1 in a closed transition transfer. At this point, the system will be in Normal Operating Mode.

12. Failure Modes:
    a. Breaker Failure:
        1) If main breaker M1 fails to open, the system shall isolate Bus 1 by opening the Tie Breaker.
        2) If main breaker M2 fails to open, the system shall isolate Bus 1 by opening the Tie Breaker.
        3) If tie breaker T1 fails to open, the system shall open one of the main breakers. The system shall defer to opening breaker M2 unless M2 is already open or there is not an available M1 source.
        4) If breaker M1 fails to close, the system shall close tie breaker T1.
        5) If breaker M2 fails to close, the system shall close tie breaker T1.
        6) If breaker T1 fails to close, the system shall close breakers M1 and M2.
        7) If there is a loss of utility during Maintenance Mode, the system shall alarm with no additional breaker operations.
13. Manual Operation:
    a. Operator places 43-AM into MANUAL mode.
    b. Operator performs manual switching as required.

G. The manual operator interface shall, at minimum, comply with the following elevation:



2.11 SOURCE QUALITY CONTROL

A. 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 ANSI C37.51.

1. The PLC programmer shall be available and present at the factory site during the full factory witness testing period so that any discovered issues or necessary modifications may be addressed at that time. The same PLC programmer shall be available during the complete site start-up and testing effort (see Part 3) and shall be present during the full site witness testing period so that any discovered issues or necessary modifications may be addressed at that time.
2. Submit all test procedures for approval and notify the Project Manager thirty days prior to commencement of any tests. Testing shall be witnessed by the Owner, and/or their duly authorized representatives. Indicate the approximate duration of the tests.

3. Provide four (4) copies of the factory test reports within two weeks of the completion of factory testing detailed herein.
4. The factory test shall be performed in the United State of America.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
   1. Transformer Tests:

      a. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
      b. Ratios on the rated voltage connection and on tap extreme connections.
      c. Polarity and phase relation on the rated voltage connection.
      d. No-load loss at rated voltage on the rated voltage connection.
      e. Exciting current at rated voltage on the rated voltage connection.
      f. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
      g. Applied potential.
      h. Induced potential.
      i. 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.
      j. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class AA rating and highest kVA Class AFA rating.
      k. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

   2. Switchgear Tests:

      a. The switchgear shall be completely assembled, wired, adjusted and tested at the factory.
      b. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment.
      c. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.
      d. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute, or 1800 volts for one second, between live parts and ground, in accordance with ANSI C37.20.1.
      e. Completely demonstrate the special provisions to accommodate switchgear maintenance.
      f. A certified test report of all standard production tests shall be shipped with each assembly.
      g. Verify mechanical operation, interlocks and interchangeability of selected breakers.

C. Factory Tests: A complete test of the custom PLC logic and other special features including actual operation of all the breakers in the switchgear to demonstrate all possible conditions of operation. All procedures for system configuration shall be demonstrated and testing shall include attempted operation of all breakers to verify proper interlocking.
   1. Provide contactors as necessary to simulate interfacing PLC control of the 480V switchgear with the medium voltage switchgear.

D. Owner will witness all required factory tests. Contractor to provide accommodations if more than 50 mi from site. Notify Owner at least fourteen (14) days before date of tests and indicate their approximate duration.
   1. Attendance or non-attendance by the Owner and/or their duly authorized representatives at factory tests shall not relieve the manufacturer of responsibility to correct any defects or items of non-conformance with these specifications discovered during site testing.

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 the 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 for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install secondary unit substations on concrete bases.
   1. Construct concrete bases of dimensions indicated, but not less than four (4) inches larger in both directions than supported unit and four (4) inches high.
   2. Use 3,000-psi, twenty eight (28) day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

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

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Arc-Flash Warning Labels:
   1. Comply with requirements in Division 26 Section 260553 "Identification for Electrical Systems." Produce 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in analysis. Labels must be machine printed, with no field-applied markings.
   2. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
      a. Location designation.
      b. Nominal voltage.
      c. Flash protection boundary.
      d. Hazard risk category.
      e. Incident energy.
      f. Working distance.
      g. Engineering report number, revision number, and issue date.

C. Labels must be machine printed, with no field-applied markings.

D. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   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 transformer enclosure and then to 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.

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 CLEANING

A. 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.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Testing: Engage a qualified independent testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
4. Set field-adjustable switches and circuit-breaker trip ranges as indicated and per short circuit analysis and recommendations of coordination.

    a. Remove and replace malfunctioning units and retest as specified above.

C. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, grounding, and required area clearances.
    c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
    d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to the address of the circuit breaker that is used to identify it in microprocessor-communication software.
    e. Verify that current and voltage-transformer ratios correspond to Drawings.
    f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

        1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
        2) Make key exchange with devices operated in off-normal positions.

g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Inspect insulators for evidence of physical damage or contaminated surfaces.
i. Verify correct barrier and shutter installation and operation.
j. Exercise all active components.
k. Inspect mechanical indicating devices for correct operation.
l. Verify that filters are in place and vents are clear.
m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of draw out disconnecting and grounding contacts and interlocks.

n. A complete test of the custom PLC logic and other special features, including actual operation of all the breakers in the Load Center to demonstrate all possible conditions of operation. All procedures and the remote/local interlocks for system configuration shall be demonstrated and testing shall include attempted operation of all breakers to verify proper interlocking.

2. Electrical Tests:

a. 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 20^0 C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. 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.

1) 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.

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

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

d. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

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

1) 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.
2) 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.

f. Verify operation of space heaters.
g. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
g. Perform specific inspections and mechanical tests recommended by the manufacturer.
h. Verify that as-left tap connections are as specified.

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

2. Electrical Tests:

a. 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.

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

1) 2.0 % for power transformers.
2) 5.0 % for distribution transformers.

c. 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.

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

e. 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.

f. 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.

g. Measure the resistance of each winding at each tap connection.

h. Perform an applied-voltage test on all high- and low-voltage windings-to-ground. See IEEE C57.12.91, Sections 10.2 and 10.9. 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 % of the ac rms test voltage specified in IEEE 57.12.91, Section 10.2, 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.

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

E. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect anchorage, alignment, and grounding.
c. Verify that all maintenance devices are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Verify that the 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 the breaker are correct.
h. Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism according to 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 according to coordination study provided by end user.
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 according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
b. Measure contact resistance across each power contact of the circuit breaker. Microohm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 % of the lowest value.
c. 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.
d. 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.

e. 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.

f. 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.

g. 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.

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

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

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

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

F. Switchgear Control System Automation – Functional Acceptance Testing

1. The manufacturer shall be onsite for commissioning services that will include a step-by-step procedure that follows the approved sequence of operations. The test script will be provided by others. It shall be the manufacturer’s responsibility to provide a fully functional system that meets every line of the sequence of operations and test script. This includes, but is not limited to, field changes required due to a failure to execute the commissioning sequence.

3.7 FOLLOW-UP SERVICE

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

1. During a period of normal load cycles as evaluated by Owner, 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 % between phases, or deviation of any

phase voltage from the nominal value by more than plus or minus 5% during the test period, is unacceptable.

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

   a. Adjust transformer taps.
   b. Rebalance loads.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report: Present field copy and prepare a written report covering monitoring performed and corrective action taken.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 261116