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BuildingName
The Description of the Project
P00000000 0000

SPECIFICATION DIVISION 26

NUMBER SECTION DESCRIPTION

DIVISION 26 ELECTRICAL
SECTION 261100 - UNIT SUBSTATIONS

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DIVISION 26 ELECTRICAL
SECTION 261100 - UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections, in particular the Related Sections listed below, apply to this Section.

B. Related Sections:

1. Section 017823 - Operation and Maintenance Manual
2. Section 019100/019110 - Commissioning
3. Section 260513 - Medium, Low & Control Voltage Cables
4. Section 260526 - Grounding and Bonding for Electrical
5. Section 260533 - Electrical Materials and Methods
6. Section 260800 - Electrical Acceptance Tests

1.2 SUMMARY

A. Provide an indoor, metal enclosed, unit substation assembly, configured as single-ended or double-ended as shown on the drawings, and consisting of primary section(s), transformer section(s), and secondary voltage distribution section(s). Provide associated controls and relays; do not provide PLC-based controls, micro-processor based human machine interfaces (HMI), or touch screen displays.

B. The substation and its major assemblies shall be designed and shipped in sections to accommodate the restricted size and configuration of the delivery route through the building, and the size of the substation room.

C. Deliver the unit substation, in one coordinated shipment, to the installing Contractor at the project site, on or before the week of _____. The project site is at _____, Ann Arbor MI 48109-2080.

D. Coordinate final delivery date, time, and other details with installing Contractor (to be named) at least 3 business days in advance of delivery date. Under Manufacturer's supervision, the installing Contractor will unload, move into position, and install the overall unit substation.

E. Provide supervision for the "breakdown" and "re-assembly" of the transformer section as needed to allow installation into the building.

F. Before energization, provide a final inspection, testing, and written certification from the equipment supplier.

G. Assist with substation start-up and commissioning activities.

H. Provide a one-year minimum warranty from the date of acceptance by the University.

I. The attached drawings are an integral part of these specifications. Carefully note the physical size of the unit, as well as shipping split and other physical restrictions noted on these drawings. Attached drawings include:

1. Drawing _____
2. Drawing _____
3. Drawing _____
4. etc…

1.3 RELATED SECTIONS

A. The drawings and the general provisions of the contract, including the current edition of the University of Michigan Standard General Conditions, apply to this section.

B. The applicable requirements of the Division 01 and other Division 26 specification sections apply to this section.

1.4 REFERENCES

A. The unit substation shall comply with the following codes and standards as applicable:

1. MV Load Interrupter Switchgear: ANSI C37.20.3 and 20.4, ANSI C37.22, NEMA SG-5, and NEMA SG-6.
2. Secondary Substation Transformers: 10 CFR Part 431, ANSI C57, IEEE 100, NEMA 201 and 210, and UL 1562.
3. LV Metal-Enclosed Switchgear Assemblies: ANSI-C37.20, NEMA SG-5, and UL 1558.
4. Low-Voltage Power Circuit Breakers: ANSI-C37.13, NEMA SG-3.
5. Circuit Breaker Trip Devices: ANSI-C37.17.
6. National Electrical Code (NEC): NFPA 70.

B. Where differences exist between various Codes and Standards, the ANSI and IEEE Standards shall govern.

C. Each of the three main sections of the substation (primary switch section, transformer section, and secondary distribution section) shall be UL listed and shall bear a UL label.

D. The secondary distribution section shall be labeled as suitable for use as service equipment unless the One Line Diagram defines the primary loop switches or primary transformer disconnect switch as the service equipment.

1.5 SUBMITTALS

A. Submit for approval the following shop drawings and product literature. Shop drawings shall contain title blocks identifying the University's project name and the University's full project number. Submittals shall be marked to indicate the specific models, sizes, types and options being provided. Submittals not so marked will be rejected.

1. Dimensioned substation plan and elevations with dimensions of the installation clearances, working clearances, conduit entry points, and base mounting points. Identify the substation front and the shipping sections.

2. Size, weight, and movement restrictions for shipping sections. Affirm that shipping sections meet noted building size and movement restrictions.
3. One line diagram including normal and fault ratings, phase rotations, and major component locations.
4. Bill of material with Manufacturers' names and model numbers for major components.
5. Enclosure details including paint color.
6. Primary switch section submittals including:
    a. Dimensioned plan and elevations with bus and switch dimensions, switch handle dimensions, and phase and ground bus terminal locations and barriers.
    b. One line diagram with bus, switch and fuse ratings, and interlock provisions.
    c. Compartment details including front door and rear panel descriptions, sheet metal gauge, and painting details.
    d. Terminal locations and details for phase and ground connections.
    e. Phase-to-phase clearances and phase-to-ground clearances.
    f. Bus bar details, connection methods, and materials.
    g. Insulator and barrier details and materials.
    h. Fuse and fuse holder descriptions.
    i. Fuse time-current characteristic curves.
    j. Nameplate engraving.
7. Transformer section submittals including:
    a. Dimensioned plan and elevations with tap, control power transformer, temperature monitor, fan and control power connection point 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, temperature alarms, hinged panel for the monitor, and control power connection points.
    h. Schematic and connection diagrams for the temperature control system.
    i. Full size copy of the nameplate.
    j. Coil-to-bus/line connection materials, supports, and details.
    k. Bus bar and line termination connection and support details.
8. Secondary voltage distribution section submittals containing:
    a. Dimensioned plan and elevations with circuit breaker, control power transformer, and metering device locations, and phase, neutral, and ground bus terminal locations.
    b. One line diagram with bus, circuit breaker, trip unit, metering device 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. Secondary metering description, including details on the current transformers, potential transformers, ammeter, voltmeter, watt-hour meter, and meter switches.
k. Schematic and connection diagrams for the secondary metering systems.
l. Nameplate engraving.

B. Prior to acceptance of the substation by the University, submit for approval, copies of installation, operation, and maintenance manuals for the following equipment:

1. Primary switches.
2. Primary fuses.
3. Transformer.
4. Transformer temperature monitor, fans, and alarms.
5. Circuit breakers and breaker lifting device.
6. Circuit breaker trip units.
7. Control power transformer.
8. Electrical metering devices.

1.6 SHIPPING, HANDLING, AND STORAGE

A. Protect the substation from weather and moisture condensation at all times.

B. Provide temporary electric heaters in the transformer in accordance with Manufacturer’s instructions until the substation is energized.

C. Notify the University and University's installing Contractor (to be named) at least 3 working days in advance of delivery.

D. Arrange for delivery of the substation at the noted site. The University's installing Contractor will unload, move, and install the unit substation under Manufacturer's direction.

E. The transformer shall be constructed so it can be broken down in the field, if necessary, so it can be lowered through the access hatch, which measures _____ x _____ clear.

F. The Manufacturer shall provide field service technicians, who will supervise the breakdown of the transformer, i.e. removing the enclosure and the secondary bus from the transformer assembly.

G. The same technicians shall supervise the reassembly of the transformer at the final installation site.

H. Ensure that all necessary extra bracing and tools required are in place, so, if necessary, the primary switches and secondary sections can be transported within the building, with their rear panel located at the bottom of transporting assembly.

I. MANUFACTURER WARRANTIES OR CERTIFICATIONS SHALL NOT BE VOIDED BY THE DISASSEMBLY AND REASSEMBLY OF THE TRANSFORMER AND SWITCHGEAR SECTIONS.

1.7 EXTRA MATERIALS

A. Deliver to the Owner the following extra materials matching the products installed, packaged with protective covering for storage, and identified with labels clearly describing the contents.

1. Spare Fuses: Provide _____for each size of:
   a. Fused primary switch power fuses.
   b. Potential circuit fuses.
   c. Control power fuses.
2. Spare Indicating Lights/Lenses: Six of each type installed.
3. Spare Kirk Keys: Two for each Kirk Key interlock.
4. Touch Up Paint: Three half pint containers or three spray cans of paint matching enclosure exterior finish.
5. Contact Lubricant: One container.

1.8 QUALITY ASSURANCE

A. Perform standard industry tests on the substation prior to shipping.

B. Provide copies of written test reports, signed and dated, for all factory and prototype tests.

C. Provide a product certification, signed and dated by the substation Manufacturer, certifying that the substation complies with the specifications except as approved by the University in writing.

1.9 WARRANTY

A. Guarantee work (parts and labor) for a period of one year from the date of the Owner’s final acceptance of the project, Substantial Completion. A manufacturer’s warranty beginning upon equipment receipt or startup shall be extended to one year from final project acceptance. A manufacturer’s warranty in excess of one year shall remain in effect for its entire time period.

1. Refer to Specification Section 011400 “Work Restrictions” for the Substantial Completion date.

PART 2 - PRODUCTS

2.1 UNIT SUBSTATION ASSEMBLY

A. The following unit assemblers are approved when they use the components specified elsewhere in this specification:

1. ABB (ASEA Brown Boveri); note that this does NOT include GE heritage products from the June 2018 acquisition
2. Eaton
3. Siemens

B. The listing of specific assemblers does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

C. The unit substation shall be a front and rear accessible structure suitable for indoor installation, consisting of primary section(s), transformer section(s), and secondary voltage distribution section(s).

1. The sections shall be constructed to allow for straightforward field assembly into a single structure.
2. 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.
3. The sections shall be capable of withstanding the lifting, skidding, jacking or rolling (in any direction) actions needed to install the equipment. Factory-installed lifting eyes shall be provided on each section.
4. The assembly shall have provisions for anchoring to steel leveling channels embedded in a concrete housekeeping pad.

D. The substation shall be a front-aligned structure. Any variations in section depth shall be reflected on the rear side of the substation.

E. The overall length of the assembly (HV switches, transformer section and secondary voltage distribution section) shall not exceed _____ feet.

F. Buses and terminations shall be:

1. Phased X-Y-Z (or A-B-C) from top to bottom, front to back, and left to right when viewed from the front.
2. Bus bars, flexible connectors, jumpers, and terminations shall be copper.
3. Bus bars, flexible connectors, jumpers, and terminations (except transformer winding terminals) shall be silver-plated before final assembly and shall be connected using two bolts minimum at each bus joint and insulator. Bolted connections shall use hex head bolts and split lock washers made of stainless steel or Grade 5 steel with clear zinc finish.
    a. The NEMA specified minimum current-carrying cross sectional area of the bus shall not be compromised by the holes needed to make bus connections.
    b. The overlap on bus connections shall be sufficient to ensure at least one bolt diameter distance from edge of bolt hole to edge of bus.

G. Phase-to-phase and phase-to-ground clearances within the substation shall reflect the specified BIL ratings.

H. Primary (medium voltage) insulators shall be porcelain or cycloaliphatic epoxy, sized to withstand the noted BIL and fault currents. When sizing the insulators, assume full load conditions and an ambient temperature of up to 40 degrees Celsius. The supports shall provide ANSI minimum creep distances between phases and ground.

I. Secondary (low voltage) insulators shall be porcelain, cycloaliphatic epoxy, or of high strength, moisture, track, and fire resistant glass polyester. Insulators shall be sized to withstand the noted BIL and fault currents, and rated for the maximum temperatures that would occur under design load and fault current conditions and an ambient temperature of up to 40 degrees Celsius.

J. Where glass polyester insulators are used, the cut edges shall be sealed to prevent moisture absorption.

K. Barriers shall be provided to enclose openings where electrical connections pass from one section to another.

L. Ventilation louvers shall be provided to dissipate the heat generated within each section. The louvers shall be located and guarded to minimize accidental contact with live parts.

M. The sections shall be painted with Manufacturer’s standard gray finish that meets the applicable standards of UL and ANSI.

N. The unit substation shall include a continuous 1/4″ by 2″, hard-drawn copper ground bus bar extending the full length across the entire unit substation bottom. In each section,(primary switch, transformer, and secondary distribution), the ground bus bar shall include a Burndy HyGround compression grounding lug suitable for a #4/0 AWG equipment grounding conductor. The ground bus bar shall be drilled and tapped at regular intervals for feeder and branch circuit grounding conductor terminals.

O. The substation shall include engraved metal or laminated plastic nameplates on the front of each section indicating ratings of equipment and Manufacturer's shop order number for the equipment. The nameplates shall consist of black letters at least 1/4-inch high on a white background. The nameplates shall be affixed with machine screws.

P. The substation shall include 1/2-inch wide minimum red acrylic mimic bus affixed with machine screws. The mimic bus shall indicate switches, transformers, circuit breakers, fuses, SPD units, terminations, fire pump tap, and similar devices.

Q. All lugs within the substation shall be of the long barrel, two-hole compression type. Mechanical lugs shall not be accepted.

2.2 PRIMARY SWITCH SECTION(S)

A. Subject to compliance with these specifications, provide products from the following Manufacturers:

1. Eaton
2. Powercon
3. Square D

B. Each primary switch section shall consist of two metal enclosed, non-fused, load break, primary loop switches as shown on the drawings, and a metal enclosed, fused, load-break, transformer disconnect switch.

C. Ratings

1. Design Voltage: 15 kV, suitable for use on a 13.2 kV grounded system.

2. Continuous Current and Interrupting Current: 600 amperes rms.
3. Momentary Short Circuit Current and Fault Closing Current: 61,000 amperes asymmetrical at the system voltage, with system impedance X/R ratio of 15.
4. Short Time (2 second) Current: 38,000 amperes symmetrical.
5. Basic Impulse Level: 95 kV.
6. Fuse Interrupting Capacity: 50,000 amperes symmetrical at the system voltage with a system impedance X/R ratio of 15.

D. Bus and Compartment Requirements

1. The phase bus bars shall be routed across the top of the compartments to eliminate unnecessary transition sections.
2. The loop switches shall be arranged for top or bottom entry of the primary cables.
3. The primary cable terminations shall be located on bus 'run-backs', near the vertical center of the compartments. A minimum of 30" of straight space shall exist above and below the terminations to facilitate installation of stress cones and to prevent bending of the primary cables to less than the minimum cable bend radius.
4. Provide side-to-side insulated cable supports above and below the 'run back' bus and connection points to relieve strain on the cable terminations.
5. Two-hole, long barrel, compression type lug terminals shall be provided in each loop switch to accept single conductor, 350 kcmil, copper, shielded cable with 15 kV, 133 percent EPR insulation.
6. The fused switch shall be cable-connected to the transformer section. Provide two-hole, long barrel, compression type lugs in the fused switch to accept the transformer primary connections.
7. The switch compartments shall be NEMA 1 rated.
8. The switch compartments shall contain hinged front doors for access to the switches and/or fuses, interlocked with the switch handles, and secured by three point latches. The hinges shall be concealed. The doors shall open a minimum of 90 degrees and be provided with door stays to prop the door open at 90 degrees. The latch handles shall include provisions for padlocking in the closed position.
9. The switches shall be provided with hinged rear doors for access to the rear cable termination areas. Rear doors shall be secured to the compartment frames with hex head machine screws and be provided with door stays to prop the door open at 90 degrees.
10. Provide heavy-duty grounding bails for all switches to accommodate portable grounding equipment.
11. In the loop switches, provide solid full height and width insulating barriers between the incoming cables section of the switch in the rear, and the energized switch and bus components toward the front portion of the switch. The primary cable terminations shall be the only energized components exposed to the rear of the compartments.

12. In the fused switch, provide a solid full height and width insulating barrier between the energized switch and bus components toward the front portion of the switch and a storage compartment in the rear of the fused switch. Provide a storage rack sized for storing 3 spare fuses in their original cartons inside the fused switch rear door.
13. The bus shall be insulated or totally enclosed by barriers, and shall not be accessible normally from either the front or the rear of the switch.
14. Provide an 8″ x 16″ minimum high-impact viewing window on the front door of each switch that permits full viewing of the position of all three switch blades. The window shall be affixed with metal through-bolts or brackets, and shall not be more than 62″ above the finished floor.

15. Provide a viewing window on the rear door of each loop switch to allow viewing of fault indicators on primary cables (fault indicators provided by Owner). The window shall be affixed approximately 18″ above the bus run backs if the cable is top entry or 18″ below if the cable is bottom entry.
16. Provide a hinged grounded metal barrier bolted closed in front of every switch to prevent inadvertent contact with any live part, yet allow for a full-view inspection on the switch blade position.
17. Provide green OPEN and red CLOSED switch position indicators with the words "Open" and "Closed".
18. The primary switch shall be removable as a complete operational component.

E. Load Break Switches

1. The switches shall be fused or non-fused as shown on the drawings, gang operated, 3-pole, and 2-position.
2. The switches shall be bottom hinged.
3. In the fused switch, the fuses shall be de-energized when the switch is open. With the loop switches, it is realized that the blade may in some cases be energized even in the open position.
4. Switch blade materials shall be copper.
5. The switch mechanisms shall be quick make, quick break, and stored-energy type, providing quick operation independent of handle speed.
6. The switch mechanisms shall be direct coupled. Chain or cable drives are not acceptable, except if supplied as a complete unit (switch, operator, and enclosure) from Powercon ONLY.
7. Glass polyester phase barriers shall be provided for the full length of the switches and fuses for each pole. The barriers shall be easily removable, and shall allow for visual inspection of the switches and fuses with the barriers in place.
8. The switches and operators shall be rigidly supported entirely from the interior framework of the compartments.
9. The external manual operating handles shall include lock open and lock closed padlocking provisions for multiple padlocks. The handles shall not project more than 6 inches in front of the substation when the switches are in the open or closed position.
10. The fuses shall be located for easy removal and replacement from the front.

11. The fuses shall be separated from the switch and bus components by the minimum clearances specified by the fuse Manufacturer.
12. Mechanical interlocks shall prevent the opening of the compartment doors unless the switches are open, and to prevent the closing of the switches if the compartment doors are open.
13. Provide switch handle position switches within the front section of each switch for remote indication. Wire the position switches to a terminal block in the rear section of the switch and from there to the control cubicle.
14. A Kirk Key interlock shall prevent the opening or closing of the fused switch unless the secondary main breaker is open. The interlock shall be arranged so that the same key required for fused switch operation is held captive at the secondary main breaker unless the breaker is in the open position.

F. Primary Fuses

1. Primary fuses shall be of the current limiting type.
2. Fuses shall be Mersen (formerly Ferraz Shawmut) Type CL-14, GE Type EJO-1, or Eaton Type 15CLE.
3. The substation manufacturer shall provide "E" rating that is consistent with the coordination of the substation main and feeder circuit breakers as well as utility and fire pump disconnects, that the momentary and interrupting ratings of the substation are within acceptable limits, and that the fuses will operate within the damage curve of the supplied transformer.
4. U-M Primary Systems Engineer and Engineer-of-Record shall agree on rating or work with manufacturer to propose an alternate rating after review of the coordination study.
5. Provide a metal or laminated plastic nameplate on the front door of the fused switch indicating the fuse type, fuse rating, and the identification number of the time-current curve.

2.3 TRANSFORMER SECTION(S)

A. Subject to compliance with these specifications, and the special shipping and installation requirements noted in Part 1 of these Specifications, provide products from the following Manufacturers:

1. ABB (ASEA Brown Boveri); note that this does NOT include GE heritage products from the June 2018 acquisition
2. Eaton
3. MGM
4. Olsun
5. Siemens
6. Square D

B. Each transformer section shall consist of a dry-type transformer with fans, temperature controls, and any transitions required to connect to the substation primary and secondary sections.

C. Ratings

1. Type: Air self-cooled and fan cooled, ventilated, dry-type.
   a. Capacity: _____/_____/_____ kVA, AA/AA/FA.
   b. Phase: 3.
   c. Frequency: 60 Hertz.
   d. Primary Voltage: 13.2 kV, delta connected.

e. Secondary Voltage: ____/____ volts, 4 wire, wye connected, solidly grounded.
f. Withstand Rating: Suitable for a maximum available primary fault of 750 mVA with a system impedance X/R ratio of 15.

2. Insulation Class: 220 degrees C.
3. Insulation Temperature Rise: 115 degrees C maximum rise above a 40 degrees C maximum ambient. The transformer shall be capable of carrying a minimum of 15 percent continuous overload without exceeding a 150 degrees C rise in a 40 degrees C maximum ambient.
4. Insulation Basic Impulse Level:
   a. 95 kV BIL on the 13.2 kV primary
   b. 10 kV BIL on the secondary
5. Impedance: 5.75 percent (from 5.32 to 6.18 percent) on the base rating of the transformer.
6. Efficiency: In accordance with Federal requirements for energy efficient transformers contained in 10 CFR Part 431.
7. Sound level: 3 dBA below NEMA standard when tested in accordance with NEMA TR-1.
8. Harmonic Rating: None.

D. Core Requirements

1. The core shall be constructed with three or four legs.
2. The core shall consist of high grade, grain oriented, non-aging, high permeability silicon steel laminations with progressively stepped, rigidly clamped joints.
3. The core’s magnetic flux density shall be well below the saturation point.
4. The core shall be grounded by use of a removable flexible ground strap between the core and ground bus.

E. Coil Requirements

1. The coils shall be copper. Inter-phase connections shall be copper.
2. The coils shall be wound with the secondary winding inside the primary winding.
3. Ventilating ducts shall provide proper cooling under all load conditions.

F. Assembly Requirements

1. The coils shall be rigidly clamped to the core to prevent movement during short circuit conditions.
2. The assembled core and coils shall be vacuum pressure impregnated (VPI) polyester, with clean insulating varnish, and then baked. Coils containing debris baked into the varnish are not acceptable.
3. The core and coils shall be mounted on vibration isolators to mechanically isolate them from the frame and enclosure for sound reasons. These isolators shall also electrically isolate the core and coils for testing purposes.

G. Taps

1. Provide five full capacity, 2.5 percent taps on the primary winding, two below and two above the nominal voltage tap of 13.2 kV.

2. Jumper cables between taps shall be supported to prevent whipping during a fault.

H. Primary and Secondary Connections

1. The primary connections shall be of the flexible cable type. These primary connections shall be supported and shall pass through the primary switch/transformer barrier through smooth grommeted, insulated bushings.
2. The secondary connections shall be of the braced bus bar type, equipped with flexible straps for vibration isolation.
3. The primary connections shall accept a minimum of two-bolts and the secondary connections shall accept a minimum of four bolts.

I. Cooling Fans

1. Cooling fans shall be of the propeller type, direct drive, with 120 VAC, single phase, TEFC motors. The motor circuits shall be fused or thermally protected.
2. Power for the fans and controls shall come from a control power transformer in the secondary distribution section.
3. The transformer temperature shall be monitored and the cooling fans shall be controlled by a Qualitrol, Cimco, or Eaton TC-100 temperature monitor.
   a. The temperature monitor shall be rated 120 volts and mounted flush on the front of the transformer, approximately 54" above the finished floor.
   b. The temperature monitor shall be mounted on a hinged front plate of a flush mounted box. The electrical connections shall be accessible and the monitor shall be removable without de-energizing the transformer.
   c. Wiring to the temperature monitor shall be routed and supported independently of the transformer enclosure so that enclosure panels can be removed without affecting the wiring.
   d. The temperature monitor shall include three hot spot temperature sensors, one for each transformer phase.
   e. The temperature monitor shall start the fans at a temperature of 100 degrees C. It shall initiate an audible alarm, close an “alarm” contact and illuminate a red alarm LED at 135 degrees C. It shall close a breaker “trip” contact and illuminate a second red alarm LED at 175 degrees C. The temperature set points shall be adjustable. The contacts shall be Form C and wired out to a terminal strip inside the temperature monitor box and are to be left for future use.
   f. 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. A reset button shall be provided to reset the maximum readings.
   g. The temperature monitor shall include LED’s indicating "power on" and "fans running".
   h. The temperature monitor shall include an RS-485 data port for future connection to a remote monitor.
   i. The temperature monitor shall include a Hand - Auto control switch connected in parallel with the temperature monitor fan control contacts.

j. Power for the temperature monitor shall come from the control power transformer located within the secondary section.
k. Provide sufficient wire coiled up to extend between the temperature monitor and the control power transformer.

J. A metal nameplate conforming to NEMA standards shall be mounted on the front of the transformer.

2.4 SECONDARY VOLTAGE DISTRIBUTION SECTION

A. Subject to compliance with these specifications, provide products from the following Manufacturers:

1. ABB (ASEA Brown Boveri); note that this does NOT include GE heritage products from the June 2018 acquisition
2. Eaton
3. Siemens

B. Single-ended unit substation secondary distribution section shall consist of two or more metal enclosed vertical stacks housing a main circuit breaker, feeder circuit breakers and circuit breaker spaces (as shown on the drawings), a control power transformer, a secondary metering compartment including CTs and PTs, and accessories.

C. Double-ended unit substation secondary distribution section shall consist of four or more metal enclosed vertical stacks housing two main circuit breakers, tie circuit breakers, feeder circuit breakers and circuit breaker spaces (as shown on the drawings), circuit breaker controls, two control power transformers with transfer switch, two secondary metering compartments including CTs and PTs, and accessories.

D. If required, provide a fire pump feeder breaker vertical section between the transformer section and secondary main breaker section. The fire pump feeder breaker section shall be completely barriered from the transformer and secondary sections and shall not contain any equipment except fire pump feeder breaker, and associated metering CTs and PTs. The feeder breaker shall be equipped with an approved physical means to protect the breaker from being inadvertently tripped by a bystander. The section shall comply with all requirements of NEC Articles 230 and 695.

E. Ratings

1. Voltage: _____/_____ volts, 4-wire, wye connected.
2. Current: _____ amps.
3. Phase: 3.
4. Frequency: 60 Hertz.
5. Insulation Basic Impulse Level: 10 kV BIL.
6. Bus Bracing: The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current _____,_____ amperes symmetrical at rated voltage. The bus system shall have a minimum ANSI 4-cycle short-circuit withstand rating of 100,000 amperes symmetrical. Circuit breakers shall have a minimum symmetrical interrupting capacity of _____, _____ amperes.

8. To ensure a fully selective system, circuit breakers shall have 30 cycle short-time withstand ratings equal to their symmetrical interrupting ratings as follows regardless of whether equipped with instantaneous trip protection or not:
   a. For 800-2000 AF frame size, short time rating shall equal symmetrical rating up through 65,000 amperes.
   b. For 3200 AF frame size, short time rating shall equal symmetrical rating up through 85,000 amperes.
   c. For greater than 3200 AF frame size, short time rating shall equal symmetrical rating up through 100,000 amperes.

F. Bus and Compartment Requirements

1. Neutral bus shall be rated at 100 percent of the ampacity of the phase buses. The neutral bus shall be isolated from ground and the enclosure. The neutral bus shall be equipped with compression lugs for terminating circuit neutral conductors.
2. Blank compartments are not permitted. Spaces shall be fully bused, fitted with neutral current sensors rated to match the breaker frame sizes, and ready to accept future circuit breakers.
3. Provide a rear compartment barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.
4. Provide a metal barrier full height and depth between adjacent vertical structures in the cable compartment.
5. Compartments shall be arranged for top entry of the secondary cables, and shall include adequate space and support members for installing and supporting the feeder cables.
6. Circuit breaker compartments shall include hinged front doors secured by thumbscrews, three point latches, or single quarter-turn latches.
7. Enclosure shall include removable top and rear panels. The panels shall be secured to the compartment frames with hex head machine screws.

G. Circuit Breakers

1. Circuit breakers shall be individually mounted, draw out, metal enclosed, stored energy type, quick-make and quick-break air circuit breakers.
2. Tie breaker(s) shall be identical to the main breakers and shall be capable of being exchanged with either main breaker.
3. Main breaker(s) shall be electrically operated and charged. The feeder breakers shall be manually operated and charged.
4. Electrically operated breakers shall use a dedicated and removable charging motor that is included with the substation.
5. Electrically operated breakers shall be equipped with open and close push buttons and position indicating lights.
6. Breakers shall be equipped with removable arcing contacts and operation counters.
7. Breakers shall be rated for 100 percent continuous duty, with frame and trip ratings as shown on the drawings.
8. Breakers shall be capable of being manually racked into three positions; “connected”, “test”, and “disconnected”. The breaker frames shall be grounded in all positions.

9. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.
10. A breaker shall be tripped open and the stored energy in the breaker mechanism shall be discharged as the breaker is moved into the disconnected position.
11. Breaker compartments shall be dead-front. Shutters shall close automatically as a breaker is racked into the test or disconnected position. Control contacts shall be 'made' when breaker is in test or connected positions.
12. Breakers shall have a minimum of two spare "Form C", isolated contacts brought out to an accessible terminal strip in the compartment. The contacts shall be rated 120 volts, 10 amperes, 60 Hz.
13. Each breaker shall be equipped with three phase current sensors, neutral current sensor, and a microprocessor-based trip unit.
    a. Current sensors shall be rated to match the frame sizes of the breakers, except current sensors for breakers with trip ratings less than 50 percent of their frame sizes shall match the breaker trip ratings.
    b. Current sensors shall be rated for 100 percent continuous duty.
14. Where shown on the drawings, breakers shall be equipped with a shunt-trip device. The shunt trip device shall be a hinged armature device rated for operation at 120 volts AC. The shunt trip wiring shall be terminated on an accessible terminal strip in the breaker compartment.
15. Breakers shall be capable of being padlocked in the "open" position.
16. A Kirk Key interlock shall be provided to prevent the operation of the fused primary switch unless the main breaker is open.
17. A Kirk Key interlock shall be provided to prevent operation of the tie breaker unless one of the main breakers is open.

H. Solid State Trip Units

1. Solid-state trip units shall be provided on all secondary main and feeder breakers. Units shall be rated as indicated on the drawings. Trip units shall be true RMS sensing. Trip units shall be magnitude and time adjustable, and shall include local and remote indication of the cause of a trip.
2. Trip units shall allow adjustment without breaker trip. Using the test kit to inject a signal to test a breaker can cause the breaker to trip.
3. Trip units shall be rated for 100 percent continuous duty.
4. Trip units shall provide the following ranges and functions as a minimum:
    a. Long time (L) current settings of at least 50-100 percent of the current sensor rating, divided into seven or more steps, and time delays of at least 2-22 seconds, at 600 percent of the long time current setting, divided into seven or more steps.

b. Short time (S) current settings of at least 250-1000 percent of the long time current setting, divided into seven or more steps, and time delays of at least 0.1-0.5 seconds, divided into seven or more steps, to include "flat response" and "I^2T response" characteristics.
c. Instantaneous (I) settings of at least 200-1000 percent of current sensor rating. The instantaneous setting shall be provided on the feeder circuit breakers only. If it is provided on the main breaker, it shall be capable of being defeated.
d. Ground fault (G) current settings of 25-100 percent of current sensor rating, with a 1200 ampere maximum, divided in seven or more steps, with ground fault time delay settings of at least 0.1-0.5 seconds, divided into five or more steps, to include "flat response" and "I^2T response" characteristics.

5. Additional functions:
a. Trip units shall provide the ability to field-select either instantaneous, short time pick-up and delay, or both instantaneous and short time protective functions.
b. Trip units shall provide integral metering functions including an integral keypad and back-lit graphical display capable of displaying:
1) voltage
2) amperage
3) power factor
4) frequency
5) watts
6) volt-amperes
7) crest factor
8) ampere demand
9) watt demand
10) voltage and current unbalance
11) fault current levels phase-phase, phase-neutral, and phase-ground
12) time-stamped event logs
13) trip logs
c. Trip units shall be equipped to provide alarms based on primary over-current, ground over-current, over ampere demand, over kW, over kW demand, over kVAR, over kVA, and phase sequence. The alarms shall have separate adjustable pick-up and delay settings.
d. Trip units shall be equipped to provide selective alarm and breaker tripping functions based on neutral over-current, current unbalance, under/over-voltage, voltage unbalance, and under/over-frequency.
e. Trip units shall be equipped to provide digital harmonic sampling capability through at least the 13^{th} harmonic.

f. The main and tie circuit breaker trip unit(s) only shall include technology to reduce arc flash incident energy during maintenance activities. This technology shall reduce the trip unit instantaneous trip value, arc flash incident level, and Personal Protection Equipment (PPE) level when enabled. This technology shall not compromise breaker phase protection even when enabled. When this technology is enabled and disabled, the recalibration of trip unit phase protection shall be accomplished without opening the circuit breaker door and exposing operators to energized parts.
   1) This technology shall reduce the arc flash incident energy during maintenance activities to a magnitude requiring PPE of Level 4 or less.
   2) This technology shall be enabled via a key lock switch located on the breaker trip unit or above the breaker door. An LED shall provide confirmation of protection and shall be blue in color.

6. Trip units shall have open protocol communication features (Modbus/TCP) including remote monitoring of power metering functions, remote open/close control of electrically operated breakers via communications, remote trip unit configuration, and remote alarming based on metered values.
7. Power for operating trip units shall be obtained from within the circuit breaker assembly itself, or by a separate control circuit connected to the secondary bus ahead of the secondary main breaker. The solid-state trip units shall have non-volatile memory to maintain all settings, trip indications, and fault data during a power outage. Batteries should not be required to maintain the memory. If batteries are required, the battery shall be capable of replacement without taking the breaker out of service.

I. Circuit Breaker Controls

1. For double-ended substations, provide main and tie circuit breaker controls to automatically or manually transfer one or both secondary main buses to the opposite power source. When transferring or retransferring an energized bus to the opposite power source, the transfer shall be closed-transition. Circuit breaker tripping shall always be available, regardless of control logic.
   a. Provide an automatic-manual selector switch (43) to automatically or manually transfer one or both secondary main buses to the opposite power source.
   b. Provide a breaker trip selector switch (10).
   c. Provide a sync check relay (25).
   d. Provide main breakers and tie breaker with relays as needed for the sequence of operations specified below. PLC-based systems shall not be provided. Provide relays for main breakers on line side of breaker with current limiting fuse protection. Provide disconnect point for test purposes to simulate undervoltage conditions.
      1) Provide sensors to detect low voltage on any phase of either secondary bus. The low voltage setpoint shall be field adjustable between 80% and 100% of nominal.

2) Provide time delays to control the timing of breaker operation. Transfer time delays shall be field adjustable between 1 and 10 seconds. Retransfer time delays shall be field adjustable between 1 second and 30 minutes. The time that the breakers may be in closed transition shall be field adjustable between 5 and 30 cycles.
3) Provide hand-reset lockout relays to prevent closing tie breaker under lockout conditions for either automatic or manual operation.

2. Sequence of Operations
a. Normal Conditions
1) Main breakers (52-A and 52-B) are closed.
2) Tie breaker (52-AB) is open.
b. Initial Start-Up
1) Verify mode selector switch (43) is in the “MANUAL” position.
2) Verify all transfer related circuit breakers are in the fully connected position in their cells.
3) Open and close breakers (using breaker control switches) to obtain normal operating conditions (refer to normal conditions below).
4) Place mode selector switch (43) in the “AUTOMATIC” position.
c. Interlocking
1) During retransfer in automatic mode, or when gear is in manual mode, both main and tie breakers may not be closed simultaneously unless buses A and B are synchronized. Interlocking is not active with one or more of the transfer breakers in the “TEST” or “DISCONNECT” position.
2) Closing and tripping of main and tie breakers via control switch is permitted when mode selector switch (43) is in the “MANUAL” position only.
d. Lock-out
1) Overcurrent trip switch (OTS) on main and tie breakers are incorporated in the control scheme such that there will be no closure of any breaker onto a fault. The scheme cannot be defeated and is active at all times.
e. Sequence of automatic transfer operation
1) Sequence A - Normal line or any single phase voltage at main 52-A drops below the 85% nominal line voltage.
a) Undervoltage relay (47-A) detects loss of voltage.
b) Time delay (62-A), adjustable from 1 to 10 seconds.
c) Main breaker 52-A opens.
d) Tie breaker 52-AB closes.
2) Sequence B - Normal line or any single phase voltage at main 52-B drops below 85% nominal line voltage.
a) Undervoltage relay (47-B) detects loss of voltage.
b) Time delay (62-B), adjustable from 1 to 10 seconds.
c) Main breaker 52-B opens.
d) Tie breaker 52-AB closes.

3) Sequence C - Normal line or any single phase voltage at both main breakers 52-A and 52-B drop below 85% nominal line voltage.
   a) No action is taken.
4) Sequence D – Where main breaker 52-A is closed, main breaker 52-B is open, the tie breaker 52-AB is closed, line and each phase voltage at main breaker 52-B returns to 95% or more of nominal line voltage, and normal line or any single phase voltage at main 52-A drops below the 85% nominal line voltage.
   a) Undervoltage relay (47-A) detects loss of voltage.
   b) Time delay (62-A), adjustable from 1 to 10 seconds.
   c) Main breaker 52-A opens.
   d) Main breaker 52-B closes.
5) Sequence E – Where main breaker 52-A is open, main breaker 52-B is closed, the tie breaker 52-AB is closed, line and each phase voltage at main breaker 52-A returns to 95% or more of nominal line voltage, and normal line or any single phase voltage at main 52-B drops below the 85% nominal line voltage.
   a) Undervoltage relay (47-B) detects loss of voltage.
   b) Time delay (62-B), adjustable from 1 to 10 seconds.
   c) Main breaker 52-B opens.
   d) Main breaker 52-A closes.

f. Sequence of automatic (closed transition) retransfer operation
1) Sequence F - Line and each phase voltage at main breaker 52-A returns to 95% or more of nominal line voltage (following “Sequence A” or “Sequence D” above)
   a) Undervoltage relay (47-A) detects normal voltage.
   b) Time delay (2-A), adjustable 1 to 100 seconds.
   c) Synchronization of main sources detected by sync check relay (25).
   d) Main breaker 52-A closes.
   e) Time delay (2-T), adjustable 5 to 30 cycles.
   f) Tie breaker 52-AB opens.
2) Sequence G - Line and each phase voltage at main breaker 52-B returns to 95% or more of nominal line voltage (following “Sequence B” or “Sequence E” above)
   a) Undervoltage relay (47-B) detects normal voltage.
   b) Time delay (2-B), adjustable 1 to 100 seconds.
   c) Synchronization of main sources detected by sync check relay (25).
   d) Main breaker 52-B closes.
   e) Time delay (2-T), adjustable 5 to 30 cycles.
   f) Tie breaker 52-AB opens.

g. Manual interlock bypass operation
1) Place mode selector switch (43) in the “MANUAL” position.

2) Place breaker manual trip selector switch (10) in the “MAIN A”, “MAIN B”, or “TIE A-B” position.
3) Open transfer breaker may be closed via breaker control switch when the remaining two transfer breakers are closed and buses A and B are synchronized.
4) Time delay (2-T), adjustable 0.1 to 10 seconds. The breaker selected by the breaker trip selector switch (10) will open.

J. Control Power Transformer

1. Provide a control power transformer with primary and secondary fusing to supply power needed by the transformer temperature monitor, cooling fans, electrically operated breakers, and other equipment needing 120 volt control power. Place the transformer and fusing in a secondary compartment.
   a. Locate the transformers and fusing in cubicles.
   b. Connect one transformer ahead of each main breaker.
   c. Provide a control power transfer circuit that automatically transfers the control circuit from one control power transformer to the other.
2. Provide a terminal block for the wiring connecting the control power transformer to the transformer temperature monitor and cooling fans.
3. Size the control power transformer to 125 percent of the anticipated maximum load (include the load of known future equipment when sizing).
4. 208Y/120-volt substations do not need dedicated control power transformers, but the circuit shall be fused regardless.

K. Secondary Metering

1. Metering equipment shall be mounted so the top of meters (or switches) is no greater than 68 inches above bottom of switchgear.
2. Instrument Transformers
   a. Provide three potential transformers with a secondary voltage of 120 volts, a mechanical rating equal to the momentary rating of the circuit breakers, and an ANSI accuracy class of 0.3.
   b. Potential transformer leads shall contain current limiting fuses. The fuses shall be accessible so that they can be maintained without shutting down the substation. 208Y/120 volt substations do not need potential transformers, but shall be fused regardless.
   c. Provide three current transformers with a ratio that is equal to one-half of bus rating, a 5 ampere secondary, a service rating of 2.0, and an ANSI accuracy class of 0.3 or better. The current transformers shall be sized to carry, at rated accuracy, 133 percent of the burden of all equipment connected to them. The minimum burden rating shall be B0.5 (12.5 VA). Current transformers shall be capable of sustained primary current levels of 200 percent of nameplate rating.

d. Locate the current transformers before the main breaker to include measurement of fire pump tap current. Locate shorting terminal blocks adjacent to their current transformers.
    1) Current transformers shall be installed so that their nameplates are readable.
    2) Current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks located adjacent to the CTs before connecting to any other devices. Shorting screws with provisions for storage shall be provided. A second set of similar shorting terminal blocks shall be provided in the control compartment.

3. Ammeter and Voltmeter
    a. The meters shall be 4.5 inch diameter or 6 inch square, flush or semi-flush, with 1 percent accuracy, anti-parallax 250 degree scales, and external zero adjustment.
    b. The ammeter shall have a maximum reading equal to twice the rating of the current transformers and the full scale reading shall be equal to 10 Amps.
    c. The voltmeter shall have a maximum reading of 240-volts on a 208-volt secondary, or 600-volts on a 480-volt secondary.
4. Instrument Switches
    a. Instrument switches shall be of the rotary type with an "off" position between each “phase” position.
    b. The voltmeter switch shall permit the reading of all phase-to-phase and phase-to-neutral voltages.
    c. The ammeter switch shall permit the reading of all phase currents, and shall maintain current transformer secondary circuits closed at all times. It shall be rated for at least 10 amps.
    d. The switches shall be mounted under their associated meter, and they shall include appropriate escutcheon plates.
5. Kilowatt-Hour Meter:
    a. The kilowatt-hour meter shall be a transformer rated (minimum Class 10) polyphase electronic meter, ION8650 series as manufactured by Schneider Electric, complete with kWh energy and kW demand monitoring, drawout case, Ethernet port (10/100Base-T), RS-485 port, infrared port, 4 digital outputs, 3 digital inputs, 32MB memory, password protected; Schneider Electric catalog #S8650C4C0H6E1B0A.
6. Kilowatt-Hour Sub-Meter:
    a. Provide kilowatt-hour sub-meters for individual feeder breakers as shown on the drawings.
        1) Kilowatt-hour sub-meters shall be the same as the main kilowatt-hour meter. Ammeters, voltmeters and instrument switches are not required.
        2) Voltage signals shall be obtained from the main potential transformers.

3) Current signals shall be obtained from separate current transformers located at the feeder cable connections. Provide three current transformers with a ratio equal to one-half the feeder breaker frame size, a 5 ampere secondary, a service rating of 2.0, an ANSI accuracy class of 0.3 or better, and a minimum burden rating of B0.5.

4) Current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks located adjacent to the CTs before connecting to any other devices. Shorting screws with provisions for storage shall be provided.

b. Sub-meters shall be mounted adjacent to the main kilowatt-hour meter or in a remote panel suitable for Contractor mounting on a wall 60” above the finished floor.

7. Provide small wiring, fuse blocks and terminal blocks within the switchgear as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on Manufacturer’s wiring diagrams.
8. Provide front access to all circuit breaker secondary connection points for ease of trouble shooting and connection to external field connections without the need of removing the circuit breaker for access.
9. Provide a front or rear accessible, isolated vertical wireway for routing of factory and field wiring. Wireway covers shall be secured by thumbscrews, three point latches or single quarter-turn latches. Factory provisions shall be made for securing field wiring without the need for adhesive wire anchors.
10. All control wire shall be Type SIS. Wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances or nylon non-adhesive anchors. Adhesive anchors shall not be used.
11. Control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips and provisions for #10 AWG field connections. Each control wire shall be marked with its origin zone, wire name, and destination zone over the entire length of the wire using a UV-cured ink process.
12. Provide wire markers at each end of all control wiring. Plug-in terminal blocks shall be provided for all shipping split wires. Terminal connections to remote devices or sources shall be front accessible via doors above each circuit breaker or a wire trough in the cable compartment.

L. Engraved laminated plastic nameplates shall be provided for breakers, the metering compartment, meters, instrument switches, fuse blocks, control power transformer, PT's, and CT's. Leave adequate space above kWh meters to permit the removal of the covers.

M. The following accessories shall be provided:

1. A top mounted, manually operated, breaker-lifting device including mounting rails.
2. For NEMA 3R rated exterior unit substations with non walk-in enclosure, a portable breaker lifting device capable of working from the floor between any nearby obstructions and housekeeping pads.

3. Circuit breaker test plug and cable(s) as needed to test the breakers.
4. Meter test plug.
5. Circuit breaker trip unit test device.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation and final testing of this unit substation shall be done under a separate contract, by the installing Contractor.

B. All necessary hardware to secure the assembly in place shall be provided by the installing Contractor.

C. The installing Contractor shall install all equipment per the Manufacturer’s recommendations and the contract drawings.

D. Install all equipment per the Manufacturer’s recommendations and per contract drawings.

E. Provide a 4-inch thick minimum concrete housekeeping pad with 1″ chamfered edge for the substation. Size and shape the pad in accordance with the approved substation shop drawings. Pad shall not extend more than four inches beyond the substation footprint. Pad shall be level to within 1/8 inch per three feet or in accordance with Manufacturer’s recommendations.

F. Anchor the unit substation to the concrete housekeeping pad using concrete anchors.

G. Install fuses and set the temperature monitor, and circuit breaker trip units in accordance with the short circuit and coordination studies, the Owner’s directions, and the Manufacturer’s instructions.

H. Provide temporary heaters in accordance with the Manufacturer's instructions until the substation is energized.

I. The substation sections shall be installed and checked in accordance with the Manufacturer’s recommendations. This shall include, but not be limited to:

1. Checking to ensure that the pad location is level to within 1/8 inch per three feet of distance in any direction.
2. Checking to ensure that all bus bars are torqued to the Manufacturer’s recommendations.
3. Assembling all shipping sections, removing all shipping braces, and connecting all shipping split mechanical and electrical connections.
4. Measuring and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four-wire systems only).
5. Inspecting and installing all circuit breakers in their proper compartments.

J. Adjust taps to deliver appropriate secondary voltage.

K. Confirm operation of circuit breakers using primary current injection method.

L. Measure primary and secondary voltages for proper tap settings.

M. Megger primary and secondary windings.

N. Assist the University’s Plant High Voltage Shop and Commissioning Authority with substation testing, start-up, and commissioning activities.

O. For each kilowatt-hour meter, provide a dedicated one-inch conduit with nylon pull string from the substation to the nearest voice/data cable tray or Telecommunication Room.

P. For switch handle position switches, provide a dedicated one-inch conduit with nylon pull string from the substation to the nearest voice/data cable tray or Telecommunication Room.

3.2 FIELD QUALITY CONTROL

A. The substation's Manufacturer shall provide the services of a qualified factory-trained Manufacturer's representative to assist the installing Contractor in the installation and start-up of the equipment specified under this section for a period of two working days.

B. The substation's Manufacturer shall provide to the Owner a line item cost for each additional day of the factory-trained Manufacturer's representative services that may be required, for up to a total of seven days.

C. The Manufacturer's Representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections, and adjustments. The Manufacturer’s Representative shall provide testing of the assembly and components.

D. The Manufacturer shall provide to the installing contractor three copies of the Manufacturer's field start-up report and written certification that the equipment has been installed and assembled per Manufacturer’s direction and is approved for energization.

E. Provide the visual inspections, manual operations, and tests on systems and equipment described below. Tests shall be performed and documented by an independent testing agency.

F. Provide written test reports, signed and dated, for all tests prior to acceptance of the unit substation by the Owner. Test reports on Megger (insulation resistance), dielectric absorption, high potential and ducter (contact resistance) tests shall include the ambient temperature and relative humidity existing at the time of the tests.

G. Prior to any testing, perform visual inspections to verify the following:

1. The equipment is completely and properly installed.
2. The equipment is free from damage and defects.
3. Shipping blocks and restraints have been removed.
4. Electrical terminations have been properly tightened.
5. The equipment has been properly aligned.
6. The equipment has been properly lubricated.
7. The ventilation louvers are open and unobstructed.
8. The equipment is ready to be tested.

H. Prior to any testing, exercise mechanical devices to verify they operate properly and freely.

I. Prior to any testing, verify that all circuit breaker trip units are set in accordance with the approved short circuit and coordination studies.

J. Perform a continuity check, 2,500-volt DC Megger test, and a DC high potential test on primary switches. DC high potential tests shall be performed at 37kV on new and existing primary switches.

K. Perform a DC Megger test and a turns-ratio test on unit substation transformers. The DC Megger test shall be performed at 2,500 volts on coils rated over 600 volts, and at 1,000 volts on coils rated 600 volts and below. The turns-ratio test shall be performed on each tap.

L. Verify proper setting and operation of the fan control panel to ensure it and the fans are operable and functional. Temperature-test the probes in each winding.

M. Perform a continuity check and 1,000 volt DC Megger test on the secondary switchgear buses and on the main and feeder breakers.

N. Perform a primary current injection test and a ducter (contact resistance) test on all breakers.

O. Perform a 1,000-volt DC Megger test and a turns-ratio test on CT's and PT's.

P. Calibrate the metering.

3.3 COMMISSIONING

A. Perform Commissioning activities per Related Sections above.

3.4 TRAINING

A. Provide a qualified service technician from the Manufacturer's staff to conduct two training sessions.

B. A Manufacturer's qualified representative shall conduct two training sessions. **These services have been purchased under the substation's pre-purchase agreement, by the University.**

C. The installing Contractor shall arrange and coordinate the two training sessions, for up to fifteen Owner's Representatives. Each session shall last four hours and shall be conducted during normal workdays at a jobsite location determined by the owner. These training sessions shall take place two to four weeks AFTER the start-up of the new substation.

D. Coordinate the training session topic(s) with the Owner’s Representatives a minimum of two weeks prior to the session. Training topics may include basic substation maintenance and operation or may include detailed training on any of the substation components.

END OF SECTION 261100