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Electrical - Guide Specification

A. ELECTRICAL - AUTOMATIC TRANSFER SWITCHES

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner and in accordance with the attached design information section.

**IMPORTANT:** The Consultant shall clearly indicate in the drawings and specifications whether the PNP, NPNP and/or BIS style switches are required. Eliminate the appropriate sections of this specification if the PNP and/or the BIS features are not required.

PART 1 - GENERAL

1.01 DESCRIPTION

A. Automatic transfer switches (ATS)
   1. Styles and features
      
      Consultant shall indicate PNP, NPNP and BIS requirements here. See the guidelines listed above.

1.02 QUALIFICATIONS

A. Pre-approved transfer switches

   Consultant shall specify the approved manufacturers based on the criteria defined in the introduction to this guide specification.

   1. Approved manufacturer: Russelectric.
   2. For each project, transfer switches shall be of the same manufacturer.
   3. Pre-approval subject to the manufacturer's ability to meet ALL of the specification requirements.

B. Pre-approved accessories

   1. Selector switches shall be Electro-Switch, Series 24 or approved equal.
   2. Russelectric RPTC Microprocessor based control system
   3. Electro Industries Gauge (EIG) 200 Shark Meter I/O with Ethernet and Relay outputs cards.
1.03 RELATED SECTIONS

A. The work under this section is subject to requirements of the contract documents, including the GENERAL CONDITIONS, SUPPLEMENTAL CONDITIONS, and sections under Division-1 GENERAL REQUIREMENTS.

B. Equipment identification

C. Requirements in support of the commissioning process

D. Structural drawings and specifications for housekeeping pad construction details.

1.04 REFERENCES

A. Applicable codes, standards, and references
   1. National Electrical Code - NEC
   2. National Electrical Testing Association – NETA
   3. UL 1008 – Automatic Transfer Switches
   5. State and local codes and ordinances

1.05 COORDINATION

A. Coordinate with Inspection, Calibration and Testing section

B. Coordinate Operations and Maintenance training times with the University.

1.06 SUBMITTALS

A. General
   1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification sections.
   2. Submit detailed maintenance manuals and drawings, which include wiring diagrams, dimensions, front and side views and catalog information indicating complete electrical and mechanical characteristics.

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

B. Operations and Maintenance Manuals shall include but not be limited to wiring diagrams, bus layout drawings, dimensions, front and side views and catalog information indicating complete electrical, mechanical characteristics, startup and testing reports.

1.08 MEETINGS

A. Attend meetings with the Owner and/or Owner's representative as required to resolve any installation or functional problems.
PART 2 - PRODUCTS

2.01 AUTOMATIC TRANSFER SWITCH AND BYPASS ISOLATION SWITCH

A. General

1. Each transfer switch shall be enclosed in NEMA-1 general-purpose enclosure with front opening lockable doors. Access into enclosure shall be from the front.
2. All components of the assembly except those identified in these specifications by the manufacturer shall be a regularly manufactured product of the supplier.
3. Nameplates: Identify all equipment, operating handles, and devices on structure (exterior and interior) with engraved plastic laminated nameplates (red background with white lettering). Engraving shall identify equipment, emergency classification and supply sources to match nomenclature identification shown on equipment schematic and wiring diagrams.
4. Provide microprocessor based control system that includes:
   a. Setup, alarm acknowledgement, and review of actual data are accomplished using the controller's soft keys and VGA color display. The menu should be able to guide the user through controller setup and the entering of configuration data, including communications and timing set points, adjustable control parameters (interlocks, alarms and security), and event logging.
   b. Real-time metering of voltage (phase-to-phase and phase-to-neutral), current and power; frequency of both sources; power quality with waveform capture and historical trending.
   c. Senses Source 1 (usually the electric utility source) and Source 2 (usually the engine generator source) voltages and, by means of easy-to-see LEDs, indicates switch position and source availability. Through the menu, the user shall be able to review operational data such as active time delays, transfer inhibits, metered values, fault and alarm reports, event records, and configuration settings. The controller also automatically displays the status of monitored conditions in color-coded banners at the top of the VGA screen including faults and alarms, inhibits, and informational messages.
   d. Two communication interfaces - standard Modbus RTU and Modbus TCP/IP via 10/100 Base-T Ethernet
   e. An external USB communication port on the controller's faceplate.
   f. Controller design shall accommodate the addition of accessories.
5. Identify all control wire terminations by tubular sleeve-type markers to agree with wire marking identification on manufacturer's equipment drawings.
6. Indicating lamps shall be LED.
7. All transfer switches shall be provided with a connection to the UW FacNet system.

B. Automatic transfer switch ratings and performance
1. Transfer to emergency and re-transfer to normal source shall be automatic. Once initiated, NPNP transfer time shall not exceed 1/20th of one second. UL 1008 listed meeting tables 21.1, 23.1, 23.2.
2. The transfer switch shall be capable of transferring successfully in either direction with 70% rated voltage applied to the switch terminals.
3. Each automatic transfer switch shall be rated at 480 volts, 3 phase, 4 pole, for 60 Hertz, normal and emergency sources.
4. All current-carrying parts shall have full 600-volt insulation.
5. The automatic transfer switch and bypass/isolation switch shall have 42,000 Amps minimum RMS short circuit withstand and closing rating when connected to the load side of standard circuit breakers (not current limiting).

C. Construction
1. For NPNP applications, the transfer switch actuator shall be double throw, single electrical operator, momentarily energized; connected to the transfer mechanisms by a simple over-center-type linkage.
2. The transfer switch shall be equipped with a permanently attached safe manual operator design to prevent injury to operating personnel. The manual operator shall provide the same contact-contact transfer speed as the electrical operator to prevent switching the main contacts slowly, and shall allow for manual transfer under full load.
3. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing.
4. Main contacts shall be mechanically locked in position in both the normal and emergency positions.
5. Main contacts: Silver tungsten alloy. Separate arcing contacts, with magnetic blowouts. Interlocked molded case circuit breakers or contactors are not acceptable.

D. The automatic transfer switch features and accessories:
1. All contacts shall be Form-C dry contacts and wire to a dedicated terminal strip for easy access and connection to remote system.
2. Number the terminals clearly and sequentially with labels indicating which function each terminal block represents.
3. Acceptable nomenclature is “Normal Position (N.O.)” or “Normal Position (Common)” where (N.O.) is the normally open contact and common is common with both (N.O.) and (N.C.).
4. Required remote monitoring contacts and signals
   a. Normal position; four auxiliary contacts closed in normal position (Russelectric #14ax).
   b. Emergency position; four auxiliary contacts closed in emergency position (Russelectric #14bx).
   c. Automatic switch truck position (Russelectric # IS). Normally open dry contact that closes when the ATS is isolated.
5. Adjustable close differential 3-phase sensing relay energized from the normal source, factory set to pick up at 90% and drop out at 80% of rated voltage. Potential transformers shall be multi-tap for either 208V or 480V sensing (Russelectric #VSN).

6. Time delay to override momentary normal source power outage, to delay transfer switch operation; adjustable 0.5 3 seconds, factory set at 3 seconds (Russelectric #1d).

7. Time delay on transfer to emergency; pneumatic type, adjustable 1-300 seconds, factory set at 3 seconds (Russelectric #2b).

8. Time delay on re-transfer to normal while in emergency position. Motor driven type, adjustable 0-30 minutes, factory set at 5 minutes. This time delay shall be overridden upon failure of the emergency source (Russelectric #3a).

   a. Manual: Permits pushbutton transfer to normal or emergency
   b. Off: Override to bypass the automatic transfer switch controls so that the transferred switch will remain indefinitely connected to the power source (emergency, normal, or neutral) regardless of the condition of the power sources.
   c. Automatic: All control features ready for automatic sensing and transfer (Exception: Remote control has priority over this switch position) (Russelectric #12a).
   d. Test: Simulates normal power failure with the load test relay (Russelectric #5c).

10. Pushbutton re-transfer to normal, operable only when the 4 position selector switch (Russelectric #6f) is in the manual position.

11. Pushbutton transfer to emergency, operable only when 4 position selector switch is in the manual position (Russelectric #6g).

12. Green LED pilot light to indicate switch in normal position (Russelectric #9a).

13. Red LED pilot light to indicate switch in emergency position (Russelectric #9b).

14. Meters using Cutler Hammer IQ200s with selector switches to read current in all three phases of load circuit. Provide shorting block and terminals for connection of 5 Amp transducer to the current transformers (Russelectric #18b).

15. Voltmeter with 7-position selector switch marked “3-1”, “2-3”, “1-2”, “Off”, “1”, “2”, “3”. Three-phase type to read phase-to-phase and phase-to-neutral voltage of the load for 4-pole ATSs. (Russelectric #18b).

16. KW and KVAR: Monitor on the load side of the transfer switch with Watt/Var transducers and related hardware. Transducer outputs shall be 4-20ma corresponding to the actual load. Hardware provided should be isolated from all other normal switch operational wiring. Include: P.T. and C.T. fuse protection, facilities for portable testing equipment (e.g. G.E. type "PK-2" test blocks), C.T. shorting blocks.

17. Loss of normal power: Six auxiliary contacts to close on failure of normal source. When applicable, these contacts shall initiate building emergency power procedures: Engine generator start contacts, HVAC control, elevator shutdown, fire alarm annunciation, etc. (Russelectric #7).

18. Contacts operated from voltage sensing network (VSN) to open on failure and close on restoration of normal source (to CMCS signal) (Russelectric #VSN).
19. Loss of emergency power: Terminals and contacts (3-amp 125 VAC) for remote monitoring of emergency source status (within voltage and frequency limits; not within voltage and frequency limits) (Russelectric #21x).

20. Derangement: Interconnect the following contacts (normally closed) such that any open contact indicates "off normal" condition, including the following:
   a. Manual/Off/Auto/Test selector switch (acc. 12) is in manual, off, or test position.
   b. Automatic mechanism of switch is fully isolated (drawn out of the cubicle).

21. Adjustable relay to prevent transfer to emergency until voltage and frequency of generating plant have reached acceptable limits. Factory set at 90% of rated value (Russelectric #21).

E. Sequence of operation

1. Contacts shall be provided to initiate an emergency operation (i.e., elevator or HVAC equipment shutdown) should the voltage of the normal source drop on any phase after an adjustable time delay of 0.5 - 3 seconds to allow for momentary dips.

2. The transfer switch shall transfer to emergency when rated voltage and frequency has been reached.

3. After restoration of normal power on all phases, an adjustable time delay period of 0 to 30 minutes shall delay the automatic re-transfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically and immediately return to the normal source or neutral position.

4. A maintained contact test switch shall be included to simulate normal power failure, and pilot lights shall be mounted on the cabinet door to indicate the switch position. Operation of test switch shall cause a derangement signal.

Consultant to include the next section for PNP style transfer switches

F. PNP switches

1. PNP applications, the transfer switch actuator shall be dual electrical operators, momentarily energized, and connected to the transfer mechanisms by a simple over-center-type linkage, with a total transfer time that is adjustable between 0 and 300 seconds.

2. PNP transfer switch styles, provide time delay relays to control contact transition time by suspending contact mechanism in neutral (off) position on transfer to either source, adjustable 1-300 seconds, factory set at 3 seconds. Timing shall start upon failure of old source. Provide terminals for remote contact control (3Amp, 120 Volt from the CMCS by others) to override relay and force ATS to assume the neutral (off) position, regardless of time delay relay status; for use in load shedding (Russelectric #2dx).

3. PNP transfer switch styles, provide a LED pilot light with a flashing lamp, which indicates when either the load shed or block transfer relays are energized (Russelectric LSBTR).

4. PNP transfer switch styles: Provide a maintained two-position selector switch for load shed or block transfer enable/disable. This switch shall be capable of being sealed in either position with a lead or plastic tamper indicating seal. Provide contacts for remote monitoring when this switch is placed in the disable position.
5. PNP applications: Provide adjustable time delays for transferring from the normal to the neutral position and from the neutral to the emergency position. A Load Shed signal shall initiate action that removes the load from the emergency source.

6. Each PNP transfer switch shall have a Load Shed Enable/Disable switch. This switch determines if the Central Management Control System (CMCS) has control.

7. PNP transfer switch styles: The CMCS shall have the ability to control loads on the campus emergency feeder system. Load Shed control takes (predetermined) prioritized loads off the system. Block transfer control permits the proper loading of the system when the generators come on line. This control shall be combined into one output signal from the CMCS.

8. Required PNP monitoring and control equipment, contacts and signals:
   a. Neutral position; four auxiliary contacts closed in neutral position.
   b. Load shed keyswitch; closed when keyswitch enabled
   c. Load Shed keyswitch; enables/disables remote load shed control

*Consultant to include the next section for BIS style transfer switches*

G. Bypass/Isolation Switch (BIS)

1. Automatic transfer switch and its associated bypass/isolation switch (BIS), shall be mounted in a freestanding enclosure, and bussed together with copper bus to provide a complete and pre-tested factory assembly. Construction shall be such that the installation contractor needs only to make the incoming power and control wiring connections.

2. Bypass/isolation switches (both normal to load and emergency to load) shall provide safe and convenient means for manually bypassing and isolating the ATS, regardless of the position or condition of the ATS, with the ability to be used as an emergency backup system in the event the transfer switch should fail. In addition, the bypass/isolation switch shall be utilized to facilitate removal of the automatic transfer switch for maintenance and repair.

3. The automatic transfer switch shall be completely isolated from the bypass/isolation switch by means of insulating barriers and separate access doors to positively prevent hazard to operating personnel while servicing or removing the automatic transfer switch.

4. Provide feeder entrance compartment at the top of switch.

5. Transfer switch removal: Provide drawout-type transfer switch that when withdrawn from its operational position is supported on a rail assembly for ease of maintenance.

6. Operation of the BIS to either normal or emergency shall be possible without changing and regardless of the position of the automatic transfer switch. Overlapping contact bypass/isolation switches that are dependent upon the position of the ATS for proper operation are not acceptable.

7. Provide indicating lights to show the bypass/isolation switch in the bypass position, in fully isolated position, and to indicate source availability. Derangement signal shall only indicate the fully isolated position (drawn out of the cubicle).

8. Accomplish positive sequencing of all contacts, with mechanical linkage which prevents delay in intermediate position, through the manual operators from a dead front location.
9. Electrical testing and maintenance of the automatic transfer switch shall be possible in the bypass position.

10. Inherent double throw (break-before-make) operation shall provide positive assurance against accidental interconnection of the normal and emergency power sources. Arrangements utilizing interlocking of single-throw devices are not acceptable.

11. The operating speed of the contacts shall be independent of the speed at which the handle is moved.

12. The BIS switch shall be fully manually operable and shall not be dependent upon electrical interlock, operators, or relays for operation.

13. All main contacts and operating linkages of the BIS shall be identical to the ATS except that the operation shall be manual, and the switch shall give the same electrical ratings of ampacity, voltage, short circuit withstand, and temperature rise capability as the associated ATS. The bypass and emergency switch shall be mechanically locked in both the normal bypass and emergency bypass positions without the use of hooks, latches, magnets, or springs and shall be silver-tungsten alloy, protected by arcing contacts with magnetic blowouts on each pole.

14. The primary buswork of the drawout automatic transfer switch shall be connected to the stationary bus stabs in the freestanding cubicle by silver-plated, segmented, self-aligning, primary disconnect stabs to facilitate proper alignment between the removable drawout element and the stationary cubicle. The ATS stab assemblies shall be drawn out when the ATS is withdrawn and shall be available for inspection without disturbing or de-energizing the main bus.

15. Similarly, the secondary control disconnect contacts mounted on the ATS shall be self-aligning and shall plug into the stationary elements mounted on the freestanding cubicle. Separate, manual, secondary control disconnect plugs are not acceptable.

16. Provide the ATS with self-contained extension rails, rollers, or casters to allow it to be rolled from its enclosure by one person.

17. Provide positive mechanical interlocks to ensure that the drawout functions can be accomplished without the danger of a short circuit.

18. Required BIS monitoring contacts and signals
   a. Bypassed to emergency position
   b. Bypassed to normal position

H. Central Monitoring and Control System (CMCS) Points List:
   1. The transfer switches shall have the capability of being supervised by the CMCS (Central Monitoring and Control System.)
      a. KW and KVAR
      b. Loss of normal power
      c. Loss of emergency power
      d. Derangement:
      e. Enclosure intrusion.
      f. Auto switch.
      g. Load Shed keyswitch.
h. Normal position.
i. Neutral position.
j. Emergency position.
k. Bypassed to emergency position.
l. Bypassed to normal position.
m. Automatic switch truck position.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Installation, mounting and electrical connections
   1. In accordance with manufacturer’s installation instructions and Seismic Zone 3 requirements
   2. Install floor mounted transfer switches on housekeeping pads. Housekeeping pads may present difficulties to remove the automatic switching mechanism for maintenance for large and heavy switches, usually 1000A and larger. For large switches, do not use pads but provide other means to prevent dust and debris from entering switch enclosures.
   3. Coordinate remote monitor and control signal connections with the University.

B. Training
   1. Provide operation and maintenance training by a factory-trained instructor for two 2-hour sessions of on-site training for a total of 6 maintenance personnel.
   2. Include troubleshooting, repair and maintenance manuals for each participant.

C. Testing
   1. Provide factory field startup and testing services to assist the ETC (Electrical Testing Contractor) per the Inspections, Calibration and Testing Section.
B. ELECTRICAL – COMMISSIONING SUPPORT

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner. Items to be modified will be decided by consultation involving the Project Manager, the A/E, and Engineering Services. The A/E is expected to modify this and other specifications as necessary to accurately reflect commissioning requirements based upon specific conditions of the project.

PART 1 – GENERAL

1.01 DESCRIPTION

A. Purpose

1. The purpose of this section is to specify Division 16 responsibilities and participation in the commissioning process.

B. General

1. Commissioning support is the responsibility of the Contractor (including subcontractors and vendors).
   a. The commissioning process requires Division 16 participation to ensure all portions of the work have been completed in a satisfactory and fully operational manner. The Contractor is responsible to provide all support required for start-up, testing, and commissioning.
   b. Division 17 is intended to provide an indication of the tests, which must be performed by the Contractor prior to verification by the Owner’s Representative and the Commissioning Agent.

2. Work of Division 16 includes the following:
   a. Start-up and testing of the equipment
   b. Assistance in testing, adjusting and balancing
   c. Operating equipment and systems as required for commissioning tests
   d. Providing qualified personnel for participation in commissioning test, including seasonal testing required after the initial commissioning
   e. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements
   f. Providing operation and maintenance information and as-built drawings to the Test Engineer for verification, organization, and distribution
Electrical - Guide Specification

B. ELECTRICAL - COMMISSIONING SUPPORT

- Providing assistance to the Test Engineer to develop and edit system operation descriptions
- Providing training for the systems specified in this Division with coordination by the Test Engineer, Owner's Representative and Commissioning Agent

1.02 RELATED SECTIONS

A. The work under this section is subject to requirements of the Contract Documents, including the GENERAL CONDITIONS, SUPPLEMENTAL CONDITIONS, and sections under Division 1 GENERAL REQUIREMENTS.

B. All start-up and testing procedures and documentation requirements specified within Division 16

C. All Division 17 commissioning procedures that require participation of Division 16

1.03 REFERENCES

A. Applicable codes, standards, and references

- All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein:

  1. International Electrical Testing Association - NETA
  2. National Electrical Manufacturer's Association - NEMA
  4. Institute of Electrical and Electronic Engineers - IEEE
  5. American National Standards Institute - ANSI
  7. State and local codes and ordinances
  8. Insulated Power Cable Engineers Association - IPCEA
  9. Association of Edison Illuminating Companies - AEIC
  11. National Fire Protection Association - NFPA
      a. ANSI/NFPA 70: National Electrical Code
      b. ANSI/NFPA 70B: Electrical Equipment Maintenance
      c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
      d. ANSI/NFPA 78: Lightning Protection Code
      f. NFPA 99: Health Care Facilities

B. All inspections and tests shall utilize the following references:

  1. Project design drawings and specifications
  2. Shop drawings and submittals
  3. Manufacturer's instruction manuals applicable to each particular apparatus
  4. Applicable NETA acceptance testing work scope sections per NETA ATS 1999
1.04 COORDINATION
   A. Coordinate the completion of all electrical testing, inspection, and calibration prior to the start of commissioning activities.
   B. Coordinate factory field-testing and assistance per the requirements of this section.
   C. The ETC (Electrical Testing Contractor) shall coordinate and cooperate in the following manner:
      1. Allow sufficient time before final commissioning dates to complete electrical testing, inspection, and calibration to avoid delays in the commissioning process.
      2. During the commissioning activities, provide labor and material to make corrections when required, without undue delay.

1.05 SUBMITTALS
   A. General
      1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

1.06 OPERATIONS AND MAINTENANCE (O&M) MANUALS
   A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

1.07 SCHEDULE
   A. Complete and make fully functional all phases of Division 16 work pertinent to the Commissioning Tests, prior to the testing date determined by the Test Engineer.

1.08 MEETINGS
   A. Attend Commissioning Meetings as required by the Contractor and/or the Test Engineer.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT
   A. Provide test equipment as necessary for start-up and commissioning of the electrical and mechanical equipment and systems.

2.02 TEST EQUIPMENT - PROPRIETARY
   A. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment.
      1. Manufacturer shall demonstrate its use, and assist the Test Engineer in the commissioning process.
2. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

B. Identify the proprietary test equipment required in the test procedure submittals and in a separate list of equipment to be included in the Operations and Maintenance Manuals.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Work prior to commissioning:

1. Complete all phases of work so the system can be started, tested, adjusted, balanced, and otherwise commissioned.
   a. Division 16 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional.
   b. This includes the complete installation of all equipment, materials, conduit, wire, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

2. A commissioning plan will be developed by the Test Engineer and approved by the Commissioning Agent.
   a. Division 16 is obligated to assist the Test Engineer in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation.
   b. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner.
   c. If Contractor-initiated system changes have been made that alter the commissioning process, the Contractor and the Test Engineer will notify the Commissioning Agent and Owner's Representative for approval.

3. Specific pre-commissioning responsibilities of Division 16 are as follows:
   a. Inspection, calibration and testing of the following equipment:
      i. Transformers
      ii. Primary switchgear and substations
      iii. Secondary switchgear
      iv. Automatic transfer switches
      v. Emergency power systems
      vi. Electrical distribution systems
      vii. Lighting control systems and lighting level verification
      viii. Fire alarm systems
      ix. Security systems
      x. Clock system
      xi. Special laboratory electrical systems
xii. Variable frequency drives
xiii. Uninterruptible power supplies

4. Normal start-up services required to bring each system into a fully operational state:
   a. These include cleaning, testing, motor rotation check, control sequences of operation, full and part load performance, etc.
   b. The Test Engineer will not begin the commissioning process until each system is complete, including normal Contractor start-up and the TAB work has been completed.

5. Commissioning is intended to begin upon completion of a system.
   a. Commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the Electrical Contractor and Electrical Testing Contractor.
   b. Start of commissioning before system completion will not relieve Division 16 from completing those systems as per the schedule.

3.02 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start up all systems within Division 16.
   1. These same technicians shall be made available to assist the Test Engineer and Commissioning Agent in completing the commissioning program as it relates to each system and their technical specialty.
   2. Work schedules, time required for testing, etc., will be requested and coordinated by the Test Engineer.
   3. Division 16 will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time, Test Engineer time, Commissioning Agent time, redesign and/or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

C. The Owner's Representative and Commissioning Agent reserve the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment or system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the Test Engineer to get the job done.

3.03 WORK TO RESOLVE DEFICIENCIES

A. In some systems, misadjustments, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems.
1. This work will be completed under the direction of the Architect and Owner's Representative, with input from the Contractor, equipment supplier, Test Engineer, and Commissioning Agent.

2. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Architect will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit timely completion of the commissioning process.

1. Experimentation to render system performance will be permitted.
2. If the Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Agent will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities.
3. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem.
4. Costs incurred to solve the problems in an expeditious manner will be the Contractor’s responsibility.

3.04 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

A. Seasonal commissioning pertains to testing under full-load conditions during peak heating and peak cooling seasons, as well as part-load conditions in the spring and fall.

1. Initial commissioning will be done as soon as contract work is completed, regardless of season.
2. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. All equipment and systems will be tested and commissioned in a peak season to observe full-load performance.

1. Heating equipment will be tested during winter design extremes.
2. Cooling equipment will be tested during summer design extremes, with a fully occupied building.
3. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance, as scheduled by the Test Engineer, with three day (minimum) advance notification.

C. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use.

1. All equipment and systems effected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance.
2. The Contractor will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.
RECOMMISSIONING

A. After the initial and peak season commissioning is completed, there may be additional work required to serve new or revised loads. This work is not part of the contract.

3.05 TRAINING

A. Participate in the training of the Owner's engineering and maintenance staff, as required in Divisions 1 and 17, on each system and related components. Training, in part, will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.

B. Training will be conducted jointly by the Test Engineer, Commissioning Agent, Owner's Representative, the design engineers, the Contractor, and the equipment vendors. The Test Engineer will be responsible for highlighting system peculiarities specific to this project.

3.06 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 1, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations.

1. All drawings shall be red-lined on two sets.

2. Division 16 as-built drawings shall include architectural floor plans, elevations and details, and the individual mechanical or electrical systems in relation to actual building layout.

B. Maintain as-built red-lines as required by Division 1.

1. Given the size and complexity of this project, red-lining of drawings at completion of construction, based on memory of key personnel, is not satisfactory.

2. Continuous and regular red-lining is considered essential and mandatory.

3.07 MISCELLANEOUS SUPPORT

A. Division 16 shall remove and replace covers of electrical equipment, open access panels, etc., to permit Contractor, Architect and Owner's Representative to observe equipment and controllers provided.

B. Furnish ladders, flashlights, tools and equipment as necessary.
C. ELECTRICAL METER AND SCADA INTEGRATION AND COMMISSIONING

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner and in accordance with the attached design information section.

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

1. The purpose of this section is to specify Contractor responsibilities and participation in the electrical meter integration and commissioning process.

B. General

1. Commissioning support is the responsibility of the Contractor (including subcontractors and vendors).

   a. The commissioning process requires Contractor participation to ensure all portions of the work have been completed in a satisfactory and fully operational manner. The Contractor is responsible to provide all support required for start-up, testing, and commissioning.

2. Work of this section includes the following:

   a. Start-up and testing of the equipment
   b. Assistance in testing, adjusting and balancing
   c. Operating equipment and systems as required for commissioning tests
   d. Provide Testing Plans to the Owner for review and approval prior to commissioning.
   e. Providing qualified personnel for participation in commissioning test, including seasonal testing required after the initial commissioning
   f. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements
   g. Providing operation and maintenance information and as-built drawings to the Owner for verification.
   h. Providing training for the systems specified in this Division with the Owner’s Representative.
1.02 RELATED SECTIONS

A. All start-up and testing procedures and documentation requirements specified within Division 26.

1.03 REFERENCES

A. Applicable codes, standards, and references - All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein:

1. International Electrical Testing Association - NETA
2. National Electrical Manufacturer's Association - NEMA
4. Institute of Electrical and Electronic Engineers - IEEE
5. American National Standards Institute - ANSI
7. State and local codes and ordinances
8. Insulated Power Cable Engineers Association - IPCEA
9. Association of Edison Illuminating Companies - AEIC
11. National Fire Protection Association - NFPA
   a. ANSI/NFPA 70: National Electrical Code
   b. ANSI/NFPA 70B: Electrical Equipment Maintenance
   c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
   d. ANSI/NFPA 78: Lightning Protection Code
   f. NFPA 99: Health Care Facilities

B. All inspections and tests shall utilize the following references:

1. Project design drawings and specifications
2. Shop drawings and submittals
3. Approved manufacturer's instruction manuals applicable to each particular apparatus
4. Applicable NETA acceptance testing work scope sections per NETA ATS 1999

1.04 COORDINATION

A. Coordinate the completion of all electrical testing, inspection, and calibration prior to the start of commissioning activities.

B. Coordinate factory field-testing and assistance per the requirements of this section.

C. The Contractor to coordinate and cooperate in the following manner:

1. Allow a minimum of 10 working days before final commissioning dates to complete electrical testing, inspection, and calibration to avoid delays in the commissioning process.
2. During the commissioning activities, provide labor and material to make corrections when required, without undue delay.

1.05 UW NETWORK INTEGRATION

A. Owner's System Integrator (SI) contractor will program the Owner's aggregation software to read the installed electrical metering and SCADA equipment. Contractor to coordinate this work with the Owner and Owner's SI contractor to ensure all programming is complete prior to commissioning.

1.06 SUBMITTALS

A. General
   1. Submitted in accordance with all Contract Documents and Division 01 Specification Sections.
   2. Contractor to provide information required on form in Appendix A and submit to Owner.

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals to be in accordance with Conditions of the Contract and Division 01 Specification Sections.

1.08 SCHEDULE

A. Complete and make fully functional all phases of electrical work pertinent to the Commissioning Tests, prior to the testing date.

1.09 MEETINGS

A. Attend Commissioning Meetings as required by the Owner.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. Provide test equipment as necessary for start-up and commissioning of the electrical equipment and systems.

2.02 TEST EQUIPMENT - PROPRIETARY

A. Proprietary test equipment required by the manufacturer, to be provided by the manufacturer of the equipment.
   1. Manufacturer to demonstrate its use, and assist the Contractor in the commissioning process.
2. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

B. Identify the proprietary test equipment required in the test procedure submittals and in a separate list of equipment to be included in the Operations and Maintenance Manuals.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Work prior to commissioning:
   1. Complete all phases of work so the system can be started, tested, adjusted, balanced, and otherwise commissioned.
      a. Contractor has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional.
      b. This includes the complete installation of all equipment, materials, conduit, wire, controls, labeling etc., per the contract documents and related directives, clarifications, change orders, etc.
   2. Complete all equipment programming prior to commissioning.
      a. Electrical Meters
         i. Meters shall be programmed prior to connecting the meter to the facility network.
         ii. Meter program parameters shall be approved by the Owner or the System Integrator.
         iii. All wiring shall be approved before being connected to the Owner's facility network.
      b. Aggregation Software
         i. Aggregation software to be programmed by the SI.
         ii. Aggregation software program parameters shall be approved by the Owner.

3. A commissioning plan will be developed by the Owner's Representative and approved by the Owner.
   a. Minimum requirements for the commissioning plan shall include the following:
      i. Verify meter part number
      ii. Review of the electrical meter's programming parameters:
         (a) Verify CT and PT ratios
         (b) Verify wiring configuration
         (c) Verify display screens are in accordance with Owner's requirements
      iii. Verify meter readings
C. ELECTRICAL METER AND SCADA INTEGRATION AND COMMISSIONING

(a) Contractor shall provide personnel support and a calibrated digital multimeter for verification of meter readings

iv. Verify electrical equipment is properly connected to the facility network.
v. Verify communication between the electrical equipment and the facility network at the facility network server.
vi. Verify all electrical equipment are being read by the Owner's Aggregation software
vii. Verify new screens are created in the aggregation software for the new electrical meters.
viii. Verify Owner's aggregation software power readings

(b) Contractor to provide personnel support and a calibrated digital multimeter for verification of meter readings

b. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner.
c. If Contractor-initiated system changes have been made that alter the commissioning process, the Contractor will notify the Owner's Representative for approval.

4. The Contractor is responsible for the installation of all equipment prior to commissioning the system. The Contractor verifies at a minimum that the following equipment is installed:
   
a. Electrical meters (includes automatic transfer switches)
b. Communication cable
c. SCADA equipment (includes automatic transfer switches).

5. Normal start-up services required to bring each system into a fully operational state:
   
a. These include cleaning, testing, phase rotation check, control sequences of operation, full and part load performance, etc.
b. The Contractor will not begin the commissioning process until each system is complete

6. Commissioning is intended to begin upon completion of a system.
   
a. Commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the Electrical Contractor and Electrical Testing Contractor.
b. Contractor shall coordinate with the SI to provide programming and configuration prior to commissioning.
c. Start of commissioning before system completion will not relieve Contractor from completing those systems as per the schedule.

3.02 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start up all systems within Division 26.
1. Contractor will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.

B. System problems and discrepancies may require additional Contractor time, redesign and/or reconstruction of systems and system components.

C. The Owner's Representative reserves the right to judge the appropriateness and qualifications of the Contractor's technicians relative to each item of equipment or system. Qualifications of Contractor's technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to get the job done in a timely manner.

D. Contractor is responsible for the removal and replacement of covers of electrical equipment, open access panels, etc., to permit Owner's Representative to observe equipment and controllers provided.

E. Furnish ladders, flashlights, tools and equipment as necessary.

3.03 WORK TO RESOLVE DEFICIENCIES

A. In some systems, misadjustments, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems.

1. This work will be completed under the direction of the Owner's Representative, with input from the Contractor and equipment supplier.

2. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Owner's Representative will have final jurisdiction over the work necessary to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit timely completion of the commissioning process.

1. Experimentation to render system performance will be permitted.

2. If the Owner's Representative deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Contractor shall schedule a meeting with the Owner to discuss the nature of the problem, expected steps to be taken, and the deadline for completion of activities.

3. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem.

4. Any costs incurred to solve the problems in an expeditious manner shall be the Contractor's responsibility.

3.04 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 1, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations.

1. All drawings shall be red-lined on two sets.
2. Contractor as-built drawings to include architectural floor plans, elevations and details, and the individual electrical systems in relation to actual building layout. Dimensions from a wall or permanent structure shall be shown for any equipment, conduit, cable, etc. installed in a different location than identified in the Contract documents.

3. All IP addresses issued to electrical meters shall be documented and included in the red-line drawings.

B. Maintain as-built red-lines as required by Division 1.

1. Red-lining of drawings at completion of construction, based on memory of key personnel, is not satisfactory.

2. Continuous and regular red-lining is considered essential and mandatory.

Device Profile Report

| Model:      |               |
| ID Number:  |               |
| Name:       |               |
| NVRAM:      |               |

Firmware Versions

<table>
<thead>
<tr>
<th>Firmware</th>
<th>Boot</th>
<th>Runtime</th>
<th>Xilinx</th>
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<tr>
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Communication Settings

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<tr>
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<th>Port 4</th>
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<tr>
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<tr>
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<td>Data Bits</td>
<td>Parity</td>
<td>Stop Bits 1</td>
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### System Setup

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<thead>
<tr>
<th>CT Ratio:</th>
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<td>Form:</td>
<td>DST Start:</td>
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<td></td>
<td>DST End:</td>
</tr>
<tr>
<td>Frequency Range:</td>
<td>Line Sync:</td>
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### Time Setup

| Frequency: |

### Demand Setup

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<th>Thermal Averaging Window:</th>
<th>Block Window Sync</th>
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<td>Use Sync Pulse:</td>
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<tr>
<td>Block Averaging Window:</td>
<td>High Speed Input #:</td>
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</table>
### C. ELECTRICAL METER AND SCADA INTEGRATION AND COMMISSIONING

<table>
<thead>
<tr>
<th>Rolling Averaging Sub-Interval Window:</th>
<th>Generate End of Interval Pulse:</th>
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<tr>
<td>Rolling Sub-Intervals:</td>
<td>Relay #:</td>
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<tr>
<td>Predictive Rolling Window Average:</td>
<td>Pulse Width (ms):</td>
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#### Limit Full Scales

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<tr>
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<th>Values</th>
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<tr>
<td>I Nm</td>
<td></td>
</tr>
<tr>
<td>V AN, BN, CN</td>
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</tr>
<tr>
<td>V AB, BC, CA</td>
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<td>V Aux</td>
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<td>Power Total</td>
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<td>Frequency</td>
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#### Flicker Settings

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<td>Long Term Test Time (PLT):</td>
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<td>Frequency:</td>
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#### I & V Squared T Thresholds

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<tr>
<th>I Squared T:</th>
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<tbody>
<tr>
<td>V Squared T:</td>
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#### Energy, Pulses, and Accumulations in the Interval

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<tr>
<th>Interval:</th>
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#### Block Window Max/Min Intervals

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<th>First (Interval 1):</th>
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<tr>
<td>Second (Interval 2)</td>
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#### Transformer/Line Loss Compensation

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<td>Apply:</td>
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<th>%LWCU</th>
<th>%LCU</th>
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## Trending Log 1 Interval

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<th>Seconds</th>
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## Trending Log 2 Interval

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## Internal KYZ Settings  Form C = KYC(Transition)| Form A = KY(Pulse)

<table>
<thead>
<tr>
<th>KYZ Output</th>
<th>Assigned Channel</th>
<th>WattHour Per Pulse</th>
<th>Pulse Width (ms)</th>
<th>Mode</th>
<th>Form</th>
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<tbody>
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<td>Test LED</td>
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## Network Settings

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<tr>
<th>IP Address</th>
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<tbody>
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</table>
### C. ELECTRICAL METER AND SCADA INTEGRATION AND COMMISSIONING

#### Gateway Port Settings

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>Gateway Port Delay</td>
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</tr>
<tr>
<td>MAC Address (IEEE Registered)</td>
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<tr>
<td>Room Physical Port Address</td>
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</tr>
<tr>
<td>MDF Switch ID</td>
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<tr>
<td>IDF Switch ID</td>
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#### DNS Servers

<table>
<thead>
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<th>Value</th>
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<td>DNS Server 1</td>
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<tr>
<td>DNS Server 2</td>
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#### Services

<table>
<thead>
<tr>
<th>Service</th>
<th>Value</th>
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<tbody>
<tr>
<td>Modbus TCP Server</td>
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<tr>
<td>Modbus TCP Client</td>
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<tr>
<td>GE EDG Data Port Server</td>
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<tr>
<td>Web Server</td>
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<tr>
<td>SMTP Server</td>
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<tr>
<td>SMTP Client</td>
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<td>FTP Server</td>
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<tr>
<td>FTP Client</td>
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<tr>
<td>HTTP/Modbus RTU Server</td>
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</table>

#### Alarm/Email

<table>
<thead>
<tr>
<th>Email Server IP Address/Name</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Email Server IP Address/Name</td>
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</tbody>
</table>
## C. ELECTRICAL METER AND SCADA INTEGRATION AND COMMISSIONING

### Email Server Port

### Email Monitor Address

### Return/Reply Address

### Email Subject Text

### Email Server Requires Authentication

### Username

### Password

### FTP Client

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<tbody>
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<tr>
<td>Startup Remote Directory</td>
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<tr>
<td>Username</td>
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<td>Password</td>
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### Network Card Firmware Update Via Network

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<tbody>
<tr>
<td>Server Port</td>
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<tr>
<td>Server IP Address</td>
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</tr>
<tr>
<td>Client IP Address</td>
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<tr>
<td>Subnet Mask</td>
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<tr>
<td>Default Gateway</td>
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<tr>
<td>Download Filename</td>
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</table>
### GE Protocol (EDG)

<table>
<thead>
<tr>
<th>IP Address for Multicast or Unicast</th>
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<tbody>
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<td>Connection Type</td>
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<tr>
<td>Update Interval</td>
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### DNP LAN/WAN Settings

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<tbody>
<tr>
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<tr>
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<td>Listen on Port:</td>
</tr>
<tr>
<td>DNP over UDP:</td>
<td>Listen on Port:</td>
</tr>
<tr>
<td>Respond to:</td>
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</table>
D. DATA COLLECTION CONTROLLER

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner and in accordance with the attached design information section.

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

1. This section covers data collection controllers for use in the Owner’s systems.

1.02 QUALIFICATIONS

A. Approved manufacturers

1. Data Collection Controllers

   a. UW Meter PLC Cabinet, Contractor to contact Campus Utilities and Operations

1.03 RELATED SECTIONS

A. 01 91 00 – General Commission Requirements
B. 23 08 00.11 – Mechanical Meter Integration and Commissioning

1.04 REFERENCES

A. Applicable codes, standards, and references codes, regulations and standards

   1. National Electrical Testing Association – NETA
   3. National Electrical Code - NEC
   4. UL 916 – Energy Management Equipment
   5. State and local codes and ordinances

1.05 COORDINATION

A. Coordinate the quantity and location of Facility Network (Facnet) Ethernet ports with Campus Engineering & Operations and UWIT. Contractor shall provide a completed “Mechanical Meter Profile Report” form per Specification 23 08 00.11 Appendix A for each meter.
1.06 OPERATIONS AND MAINTENANCE (O&M) MANUALS
   A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
   B. Operations and Maintenance Manuals shall include catalog information indicating complete electrical and mechanical characteristics.
   C. Manufacturer's Certified Test Reports

1.07 MEETINGS
   A. Pre-installation conference
      1. The Contractor shall request a pre-installation conference with the UW Engineering Services for projects requiring the installation of or the connection to a data collection controller.
      2. The Contractor shall request a pre-installation conference with Campus Utilities and Operations before project begins construction.
   B. Attend meetings with the Owner and/or Owner's Representative as required to resolve any installation or functional problems.

PART 2 - PRODUCTS

2.01 DATA COLLECTION CONTROLLER(S) AND CABINET(S)
   A. Provided by Campus Utilities and Operations. Project shall reimburse the Campus Utilities and Operations for cost of the controller and cabinet.
   B. Capacity
      1. Each data collection controller is capable of collecting 64 input points. The project shall coordinate input point quantity with the Campus Utilities and Operations to supply sufficient controllers and cabinets.

PART 3 - EXECUTION

3.01 REQUIREMENTS
   A. General installation
      1. Identification
         a. Reference section 26 05 53 Identification
      2. Installation
         a. Only personnel qualified and experienced in this type of work shall make connections.
b. The installation of data collection controllers shall be done with care to avoid damage.
   i. Controllers showing damage after installation shall be replaced.
   ii. Controllers hung improperly shall be properly secured and all paint scratches shall be touched up.
   iii. Data collection controller cabinets hung improperly shall be secured and all paint scratched shall be touched up.

c. Each controller shall have dedicated CAT5E communication cable installed to connect the controller to the facility network. UW shall make communication cable terminations. Communication conduit shall be 1” minimum.

d. Controllers shall be installed no higher than 72” above the floor.

e. Wire labels shall be machine made shrink type labels.

f. All wire must be unbroken from source to endpoint.

g. No penetrations shall be made in the back or wire way of data collection controller.

h. Penetrations made in the top of the data collection controller shall “Myers Hub” installed.
   i. IT Termination Box
      i. Shall be 12” x12” x 6” (B-Line #12126-1) with keyed lock #1333 Dirak.
      ii. Must be located in a serviceable location within 10’ of data collection controller.
      iii. Label (Brother P-touch or equal) shall be installed on inside cover indicated IT Room that service is from.

j. Owner shall verify installation prior to energizing data collection controller.

3. The System Integrator will check the Contractor’s work to ensure the accuracy of the connections.

   a. The Contractor shall arrange with the Owner for the times when their services will be required, and under no circumstances shall the Contractor connect to the existing system without Owner’s knowledge.

   b. The proper connection of the wires and cables to other systems as specified is entirely the responsibility of the Contractor.

   c. In the event the connections cannot be made as specified, the Contractor shall make the necessary corrections at his own expense.

4. Install controllers per manufacturer's recommendations.

B. Mounting and electrical connections

   1. In accordance with manufacturer's installation instructions.
   2. A dedicated 120VAC circuit from a panelboard to the data collection controller with #12 THHN/THWN in a dedicated GRC/IMC. Panelboard must be clearly labeled to show feed to data collection controller.
   3. Owner to verify power cable installation, and energize circuit after inspection.

C. UL Listing
1. The Contractor shall ensure that the controller installation is UL Listed.

D. Testing

1. Provide testing as required per Division 26 Inspection, Calibration and Testing.

E. Integration and Commissioning

1. See section D Mechanical Meter Integration and Commissioning
**E. ELECTRICAL – METER**

**GUIDE SPECIFICATION**

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner and in accordance with the attached design information section.

**PART 1 - GENERAL**

1.01 DESCRIPTION

A. Purpose
   1. This section covers electrical service meters and sub-meters for use in the Owner's power distribution systems.

1.02 QUALIFICATIONS

A. Approved manufacturers
   1. Electrical Service Meters
      a. Electro Industries – Nexus 1262
      b. Electro Industries – Shark 270 with V3 Switch Pack
      c. No Substitutions Allowed
   2. Electrical Sub-Meters
      a. Electro Industries – Shark 200 with V3 Switch Pack
      b. Electro Industries – Shark MP200 with V2 Switch Pack
      c. Eaton – PXMP Very features to make equal to Shark
      d. Eaton – PXM2260
      e. GE – EPM 4600 with Basic Logging
   3. Test Blocks
      a. GE – PK-2 #644120G3 & PK-2 #6422420G4
      b. Marathon – 1500
      c. Buss – 15149-3
      d. Or approved equal

1.03 RELATED SECTIONS

A. 01 91 00 – General Commission Requirements
B. 26 08 00.11 – Electrical Meter Integration and Commissioning
1.04 REFERENCES

A. Applicable codes, standards, and references codes, regulations and standards

1. National Electrical Testing Association – NETA
3. National Electrical Code - NEC
4. ANSI C12.20 – Accuracy
5. ANSI/IEEE C37.90.1 – Surge Withstand
6. ANSI C62.41 – Surge Immunity
7. IEC 1000-4-2 – ESD
8. IEC 1000-4-3 – Radiated Immunity
9. IEC 1000-4-4 – Fast Transient
10. IEC 1000-4-5 – Surge Immunity
11. IEC 1000-4-6 – Conducted Immunity
12. IEC 60068-2-6 – Vibration (Sinusoidal)
13. IEC 60068-2-27 – Shock Test
14. IEC 695-2-1 – Resistance to heat & Fire
15. IEC 68-2-1 – Cold Test
16. IEC 68-2-2 – Dry Heat
17. IEC 68-2-30 – Damp Heat
18. State and local codes and ordinances

1.05 COORDINATION

A. Coordinate Operations and Maintenance training times with the Owner.

1.06 SUBMITTALS

A. General

1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
2. Submit detailed maintenance manuals and drawings, which include catalog information indicating the complete electrical and mechanical characteristics.
3. Submit dimensioned cross-sectional drawings (manufacturer's data sheets are acceptable).
4. Submit finished meter tests – Manufacturer's Certified Test Reports showing compliance with ANSI C12.20 accuracy tests

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
B. Operations and Maintenance Manuals shall include catalog information indicating complete electrical and mechanical characteristics.
C. Manufacturer's Certified Test Reports
D. Manufacturer's drawings of meter wiring diagram.

1.08 MEETINGS

A. Pre-installation conference

1. The Contractor shall request a pre-installation conference with the UW Engineering Services and UW Physical Plant High Voltage Shop for projects with medium and high voltage work.

B. Attend meetings with the Owner and/or Owner's Representative as required to resolve any installation or functional problems.

PART 2 - PRODUCTS

2.01 GENERAL

A. These electrical meter specifications are in accord with the Owner's policy to construct permanent installations with long life, coupled with maximum reliability and safety.

2.02 ELECTRIC SERVICE METER

A. The following shall apply to the main electric meters at the main building service:

1. Power meter shall be multi-function 3 phase, solid-state, socket-mount design.
   a. Meter shall be capable of connection to three-phase, four-wire or three-phase, three-wire circuits.
   b. Meter shall support meter form factors 9S, 36S, and 45S.

<table>
<thead>
<tr>
<th>Form</th>
<th>Rated Voltage</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>9S</td>
<td>0 to 277 V L-N</td>
<td>3E, 4W, Wye</td>
</tr>
<tr>
<td>36S</td>
<td>0 to 277 V L-N</td>
<td>2 ½ E, 4W, Wye with Neutral</td>
</tr>
<tr>
<td>45S</td>
<td>0 to 480 V L-L</td>
<td>2E, 3W, Delta</td>
</tr>
</tbody>
</table>

2. Voltage and current inputs to the meter shall conform to the following at a minimum:

   a. Meter shall be a Class 20, transformer rated design.
   b. Monitor shall accept input of three (3) independent voltage inputs and three (3) independent current inputs of the stated capacity.
   c. Voltage inputs shall be rated for connection to circuits from 0 to 480 Volts AC line-to-neutral or 0 to 600 Volts AC line-to-line and shall be auto-ranging over this range.
d. Voltage input shall be optically isolated to 2500 volts AC. Shall meet or exceed IEEE 37.90.1 (Surge Withstand Capability). Communication ports shall be isolated from each other to 1000 Volts.
e. Current inputs shall have a continuous rating of 120% of Class Current and a 1-second over-current rating of 500 %.

3. Power meter shall measure and report the following quantities at a minimum:
   a. Voltage, both phase to neutral and phase to phase, for all three phases; Phase angles for each voltage relative to each other.
   b. Current, phase A, B, C, and N-calculated; Phase angles for each current relative to voltages.
   c. Watts (total and per phase), VARs (total and per phase), VA (total and per phase), Power Factor (total and per phase) and Frequency.
   d. Accumulated Watt-hr, VA-hr, and VAR-hr; Watt-hr received; Watt-hr delivered. VAR-hr and VA-hr reading shall be accumulated and stored for each of the 4 quadrants of power.
   e. Power demand shall be simultaneously calculated using five (5) different averaging methods: Fixed Window (Block) Average, Sliding Window (Rolling Block) Average, Thermal Average, Predicted Average, and Cumulative Demand.
   f. Power meter shall provide time-stamped maximum and minimum readings for every measured parameter, and provide coincident VAR readings for all maximum Watt readings with time/date stamp.

4. The power meter shall compensate for errors in current transformer and potential transformer.
   a. Errors shall include voltage, multipoint current, multiphase angle, and better than .01% resolution.

5. Meter shall include an integrated LCD display with multiple display modes. The display shall be fully customizable by the user.
   a. Display shall at least support simultaneous Normal, Test, Diagnostic, and Time-of-Use modes.
   b. Normal Mode shall have fully customizable screens.
   c. Test Mode shall provide access to Wh (delivered and received), VARh (delivered and received), VAh (delivered and received), and instantaneous demand. When operating in test mode the stored readings from Normal Mode shall not be impacted or compromised.
   d. Diagnostic Mode shall provide access to all voltages and currents, a real-time phasor diagram, and real-time harmonics of each voltage and current to the 40th order. Viewing harmonics to the 128th order shall be available through a connected computer.
   e. Time of Use mode shall provide access to kWh and kW for each TOU register and total, kVARh and kVAR for each TOU register and total and kVAh for each TOU register and total.
6. Power meter shall provide multiple digital communication ports and support multiple open protocols.
   a. Meter shall include an IR port for communication to external devices such as handheld readers that supports speeds of up to 57,600 bps.
   b. Meter shall include a RS-485 digital communication ports. The port shall be user configurable with regard to speed, protocol, and address.
   c. Meter shall have a second port configured as a 10/100BaseT Ethernet port.
   d. Meter shall communicate using Modbus RTU, Modbus ASCII, and Modbus TCP/IP protocols as standard configurations. All instantaneous data, logged data, and event data, information shall be available using these open protocols. The meter shall also provide means for custom modbus mapping.
   e. Meter shall include DNP 3.0 Level 2 protocol for communication to SCADA systems. All instantaneous data and average data shall be available using DNP 3.0 Level 2 protocol. User shall be able to custom map data into DNP protocol using Windows based software.

7. The meter shall internally record and store Time of Use data.
   a. The following Time of Use parameters must be included:
      i. Bi-directional consumption and demand
      ii. Eight (8) TOU Schedules
      iii. Twenty (20) Year Calendar
      iv. Four (4) seasons per year.
   b. The meter must provide the following TOU information for all rates in real-time:
      i. Current month accumulations
      ii. Previous month accumulations
      iii. Current season accumulations
      iv. Previous season accumulations
      v. Total accumulations to date
      vi. Programmable Freeze Registers
      vii. Cumulative Demand

8. Meter shall be equipped with four (4) form C pulse output channels that can be configured for operation as KYZ pulse outputs or End of Interval pulse outputs.

9. Meter shall be equipped with eight (8) pulse input channels for data collection from other meters.

10. Power meter shall be equipped with non-volatile RAM for recording logs and programming information.
    a. Meter shall include at least 512K RAM.
    b. In the event of loss of control power, data stored in memory shall be retained for at least 10 years.
c. Meter shall store all programming and set-up parameters in non-volatile memory. In the event of loss of control power, meter programming data stored in memory shall be retained for at least 10 years. No replaceable battery shall be required.

11. Meter shall record system events for security and anti-tampering.
   a. Events recorded shall include:
      i. Power up & down
      ii. Password access & modification
      iii. Change of the programmable settings & run time
      iv. Change of clock time by communication (Modbus or DNP)
      v. Test Mode usage
      vi. Meter resets (Logs, Max/Min, Energy)

12. Power meter shall be programmable by software supplied by the meter manufacturer.
   a. Software shall have a user-friendly, Windows compatible interface.
   c. Software shall include capacity to program meter, download meter, and analyze downloaded data files.
   d. Software shall store all data in an ODBC compliant database. Data based storage shall include all log and waveform data.

13. Power meter shall be appropriately constructed to provide long life in abusive physical and electrical environments.
   a. Meter firmware shall be held in flash RAM and shall be upgradeable through one of the communications port without removing the unit from service.
   b. Meter shall have a Lexan cover. An internal cover shall protect circuit boards and energized parts from UV damage or when the Lexan cover is removed for maintenance.
   c. Meter shall operate successfully at temperature extremes from –40o C to +85o C.
   d. Meter shall operate with control power from 85 to 550 volts AC. Meter shall have a power supply option to operate with an external control power input of 85 to 275 Volts AC/DC.
   e. Meter shall have a standard 4-year warranty.

2.03 ELECTRIC METERING CABINET

A. A socket based electrical cabinet shall be supplied with the electric service meters.
   1. The metering cabinet shall be an UL Type 1 or an UL Type 3R steel enclosure with factory supplied knock-outs.
   2. The metering cabinet shall have a minimum dimension of 18” x 18” x 12”.
   3. The metering cabinet shall be provided in multiple configurations to support meter forms 9S, 36S, and 45S.
   4. The cabinet shall be lockable and provide for the application of a security seal.
5. The cabinet shall be provided with a 4 pole potential test block, a voltage fuse block, and appropriately sized fuses that are prewired to the socket base.
6. The cabinet shall be provided with a 6 pole current shorting test block prewired to the socket base.
7. Metering cabinet shall be painted ANSI Z55.1 gray finish.

2.04 ELECTRICAL SUB-METERS

A. The following shall apply to single or multi circuit meters:
   1. The meter shall be UL listed.
   2. Energy meter shall be designed for Multifunction Electrical Measurement on 3 phase power systems.
      a. Meter shall support 3-Element Wye, 2.5 Element Wye, 2 Element Delta, 4 wire Delta systems.
      b. Surge withstand shall conform to IEEE C37.90.1 and ANSI C62.41 (6 kV)
      c. The meter shall be user programmable for voltage range to any CT or PT ratio.
      d. Meter shall have a burden of not more than 0.36VA per phase Max at 600V, 0.014VA at 120 Volts.
      e. Meter shall have a burden of not more than 0.005VA per phase Max at 11 Amps.
      f. The meter shall accept a voltage input range from 20 up to 576 Volts Line to Neutral, and a range from 0 up to 721 Volts Line to Line.
      g. Meter shall accept a current reading of up to 10 Amps continuous. Startup current for a 5 Amp input shall be no greater than 0.005 Amps.
      h. Meter shall come standard with one solid state KYZ pulse output for remote energy pulse counting.
   3. Energy meter shall allow all wiring through the front of the unit, so that the unit can be surface-mounted.
      a. Fault Current Withstand shall be 100 Amps for 10 seconds at 23oC.
      b. All inputs and outputs shall be galvanically isolated and tested to 2500 Volts AC.
      c. The meter shall accept current inputs of class 10: (0 to 10) A, 5 Amp Nominal, and class 2 (0 to 2) A Secondary, 1A Nominal.
   4. The meter shall include a three-line, bright red, .56” LED display.
      a. The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load bar shall have not less than 10 segments.
      b. The sub-meter must have a programmable display, which allows for the following programming functions including automatic scroll, screen selection programming, and energy scaling.
   5. Sub-meter shall be a traceable revenue sub-meter, which shall contain a utility grade test pulse, allowing power providers to verify and confirm that the sub-meter is performing to its rated accuracy.
   6. The meter shall include communications ports with advanced features.
a. Port 1 shall provide an optical IrDA port (through the faceplate) which shall allow the unit to be set up and programmed using a remote laptop without need for a communication cable.

b. Port 2 shall be RS485. The meter shall speak Modbus RTU or ASCII protocol up to 57.6K baud.

c. Port 3 shall be 10/100BaseT Ethernet. The meter shall provide an RJ45 Ethernet connection which shall allow the unit to be assigned an IP address and communicate Modbus protocol over Ethernet TCP/IP.

7. The meter shall provide user configured fixed window or rolling window demand. This shall allow the user to set up the particular utility demand profile.
   a. Readings for kW, kVAR, kVA and PF shall be calculated using utility demand features.
   b. All other parameters shall offer max and min capability over the user selectable averaging period.
   c. Voltage shall provide an instantaneous max and min reading displaying the highest surge and lowest sag seen by the meter.
   d. The Meter shall provide upgrade rate of 6 cycles for Watts, Var and VA. All other parameters shall be 60 cycles.

8. The meter shall support power supply of 90 to 400 Volts AC and 100 to 370 Volts DC. Universal AC/DC Supply shall be available and shall have burden of 16VA Max.

9. The meter shall provide Limits Alarms and Control Capability as follows:
   a. Limits can be set for any measured parameter.
   b. Up to 16 limits per parameter can be set.
   c. Limits shall be based on % of Full Scale settings.

10. The meter shall have 2 Megabytes data-logging capability. The meter shall have a real-time clock that allows for time stamping of all the data in the meter when log events are created. The meter shall have five logs:
   a. The meter shall have three historical logs for trending profiles. Each log shall be capable of being programmed with up to 64 parameters. The user shall have the ability to allocate memory between the three historical logs in order to increase or decrease the memory allotted to each of the logs.
   b. The meter shall have a log for Limits Alarms. The Limits log shall provide magnitude and duration of an event, time-stamp, and log value. The log must be capable of recording to 2048 events.
   c. The meter shall have a log for System Events. The System Events log shall record the following occurrences with a timestamp: Demand Resets, Password Requests, System Startup, Energy Resets, Log Resets, Log Reads, Programmable Settings Changes.

11. The meter shall have a standard 4-year warranty.

12. Energy meter shall be able to be stored in (-20 to +70) degrees C.
   a. Operating temperature shall be (0 to +60) degrees C.
13. The following shall be supplied for each circuit the sub meter is to be connected to:
   a. 4 pole voltage test switch, fuse block, and appropriately sized fuses
   b. 6 pole current shorting block
   c. Separate power supply for the meter.

14. Multi-Point Sub Meters shall accommodate 8-3 phase 4 wire loads.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. General installation
   1. Identification
      a. Reference section 26 05 53 Identification
   2. Installation
      a. Only personnel qualified and experienced in this type of work shall make connections.
      b. The installation of meters shall be done with care to avoid damage.
         i. Meters showing damage after installation shall be replaced.
         ii. Metering cabinets hung improperly shall be properly secured and all paint scratches shall be touched up.
      c. Each meter shall have dedicated CAT5E communication cable installed to connect the meter to the facility network.
      d. Meters shall be installed such that the display is no higher than 72’’ above the floor.
   3. System Phase Sequence is C-B-A.
   4. UW’s Physical Plant Department High Voltage Shop will check the Contractor’s work to ensure the accuracy of the connections.
      a. The Contractor shall arrange with the Owner for the times when their services will be required, and under no circumstances shall the Contractor connect to the existing system without Owner’s knowledge.
      b. The proper connection of the wires and cables to other systems as specified is entirely the responsibility of the Contractor.
      c. In the event the connections cannot be made as specified, the Contractor shall make the necessary corrections at his own expense.
   5. Install meters per manufacturer's recommendations.

B. Mounting and electrical connections
   1. In accordance with manufacturer's installation instructions.
2. Install a dedicated 120V circuit from panelboard to provide power to the electrical meter in a dedicated RGC/IMC. (if required)

C. UL Listing
   1. The Contractor shall ensure that the metering installation is UL Listed.

D. Integration and Commissioning
   1. See Electrical Meter and SCADA Integration and Commissioning
F. ELECTRICAL – INSPECTION, CALIBRATION AND TESTING

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner.

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

1. The purpose of this section is to assure that all electrical equipment, both Contractor and Owner-supplied, is operational, within industry manufacturer's tolerances, calibrated per the Power System Studies, complies with all applicable codes, installed in accordance with design specifications, and functioning in the system in the manner designed by the engineer. This effort should minimize damage and limit outages caused by electrical failures, assure proper personnel protection, and will determine suitability for reliable operation.

B. General

1. Inspections, calibrations, and acceptance tests for all equipment/systems shall be performed. The inspections and testing activities shall be divided among the following groups as specified in this section:

   a. The ETC (Electrical Testing Contractor) services shall be engaged by the electrical Contractor. The ETC shall be a recognized firm specializing in performing inspections, calibrations and acceptance tests specified in this section. The ETC shall provide all material, equipment, labor and technical supervision to perform the inspection, calibration and testing.

   b. The original equipment manufacturer's authorized service representative shall provide special equipment, labor, and technical supervision, when required, in addition to what is supplied by the ETC.

   c. Inspections, calibrations, and acceptance tests for equipment and systems not requiring the services of the ETC and manufacturer's representative shall be performed by the electrical Contractor.

2. In cases where equipment and systems requires the involvement of two or all of the parties, the parties mentioned above shall coordinate and perform all inspection and testing requirements. The Contractor shall be responsible for coordination of the work and ensuring that the requirements of this section are met.
1.02 QUALIFICATIONS

A. The Contractor shall retain the services of a third party ETC that is qualified to test electrical equipment, and is an approved testing company by the State of Washington Department of Labor and Industries. The ETC shall not be associated with the manufacture of equipment or systems under test.

B. The ETC shall have the inspections, calibration, and acceptance tests performed by or under the supervision, review and approval of a professional Electrical Engineer holding a current license from the State of Washington.

C. The Electrical Engineer shall be an employee of the testing company with at least 5 years of field experience testing electrical apparatus.

D. The testing company's site lead engineer shall be a licensed professional electrical engineer, who is a full time employee of the testing company, with at least 5 years of experience testing electrical equipment, troubleshooting and identifying power system and equipment deficiencies.

E. Pre-approved, subject to the qualifications, third party requirements and association restrictions stated in this section:

1. Siemens Technical Services
2. Sigma Six Inc
3. Electrotest, Inc.

1.03 RELATED SECTIONS

A. The work under this section is subject to requirements of the Contract Documents including the GENERAL CONDITIONS, SUPPLEMENTAL CONDITIONS, and sections under Division 1 GENERAL REQUIREMENTS.

B. Power System Protective Device Studies

C. Refer to Commissioning section for Contractor requirements in support of the commissioning process.

1.04 REFERENCES

A. Applicable codes, standards, and references:

1. All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise in this section.
   b. National Electrical Manufacturer’s Association – NEMA
   d. Institute of Electrical and Electronic Engineers – IEEE
   e. American National Standards Institute – ANSI
   g. State and local codes and ordinances
   h. Insulated Power Cable Engineers Association – IPCEA
   i. Association of Edison Illuminating Companies – AEIC
j. Occupational Safety and Health Administration - OSHA 29CFR Part 1910.269
k. National Electrical Code – NEC
l. National Fire Protection Association – NFPA
m. ANSI/NFPA 70: National Electrical Code
n. ANSI/NFPA 70B: Electrical Equipment Maintenance
o. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
p. ANSI/NFPA 78: Lightning Protection Code
r. NFPA 99: Health Care Facilities

B. All inspections and tests shall utilize the following references:
   1. Project design drawings and specifications
   2. Shop drawings and submittals
   3. Manufacturer's instruction manuals applicable to each particular apparatus
   4. Applicable NETA acceptance testing work scope sections per NETA ATS 1999

1.05 COORDINATION

A. Coordinate the Acceptance Testing with the Owner and Owner Representative.
B. Coordinate ETC and factory field-testing and assistance per the requirements of this section.

1.06 SUBMITTALS

A. General
   1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
   2. Submit the ETC qualifications according to this section for approval.
   3. Submit the coordinated test schedule for approval.
   4. Submit detailed test procedures corresponding to the requirements in this section for approval. The test procedures shall be detailed test instructions, written with sufficient step-by-step information to allow a test to be repeated under identical conditions. List the value for all setpoints and acceptable results for each condition tested.
   5. Submit a preliminary copy of the hand-written field test results to the Project Engineer and Owner's Representative no longer than one week after the test is completed.
   6. Prior to energization of equipment submit a letter certifying that the electrical installation being energized complies with contract documents, code and proper system operation.
   7. The test reports shall be compiled and submitted in formal form with a summary. The report shall be reviewed and stamped by the Professional Electrical Engineer.

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
1.08 SCHEDULING

A. Perform all testing after installation and before energizing. All systems shall pass tests prior to being put into service.

B. The Contractor in coordination with the ETC Engineer and the equipment manufacturer’s representatives shall submit to the Owner’s Representative a schedule of all tests to be performed one month prior to the scheduled performance of the first test.

C. Confirm the test schedule with the Owner’s Representative one week prior to the test. The ETC Engineer shall coordinate the test schedule so that the University’s Engineering Services and/or Physical Plant, at their discretion, can witness the testing.

D. The ETC Engineer shall deliver the test results to the University within 7 working days of test. The Owner shall have the tests results for a two-week review prior to equipment energization.

E. Testing and calibration of electrical equipment shall be completed prior to the start of commissioning activities. Refer to the commissioning specification to determine which systems are to be commissioned. When required during commissioning, the ETC Engineer shall retest and recalibrate equipment to support the commissioning activities.

1.09 MEETINGS

A. Pre-installation conference: The Contractor shall request a pre-testing conference with the University’s Engineering Services. For projects with medium/high voltage testing, the group shall include the University’s Campus Operations High Voltage Shop.

1.10 SAFETY AND PRECAUTIONS

A. Safety practices shall include, but are not limited to, the following requirements:
   1. Occupational Safety and Health Act of 1970 – OSHA
   2. Applicable state and local safety operating procedures
   3. National Fire Protection Association - NFPA 70E

B. Tests shall be performed with apparatus de-energized unless otherwise specified (e.g. rotation, phasing).

C. Power circuits shall have conductors shorted to ground by a hotline grounded device approved for the purpose.

D. In all cases, work shall not proceed until the Contractor’s safety representative has determined that it is safe to do so.

E. The ETC shall have available, sufficient protective barriers and warning signs, where necessary, to conduct specified tests safely.

F. The Owner’s safety procedures shall be reviewed and understood by the ETC.
PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. All test equipment shall be furnished by and remain the property of the Contractor.
B. Test instrument calibration
   1. The electrical testing Contractor shall have a calibration program, which maintains all applicable test instrumentation within rated accuracy.
   2. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.
   3. Up-to-date calibration labels shall be visible on all test equipment.
C. Use of torque wrenches
   1. Use calibrated torque wrenches for all bolted connections on buses and power cable terminations. Mark the head of the bolt with a colored marker pen after its being torqued to manufacturer's recommended value.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Perform acceptance tests in accordance with manufacturer's recommendations, NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1999.
B. Voltage adjustments shall be in accordance with SCL Standard E1-4.1.
C. The test plan, procedures, test results and reports shall be reviewed, under the supervision of and approved by the ETCs site engineer who is a licensed professional Electrical Engineers.
D. Division of responsibility:
   1. The Electrical Contractor shall torque down all accessible bolts, perform routine insulation resistance and continuity tests on branch and feeder circuits and rotational tests for all distribution and utilization equipment, prior to and in addition to tests performed by the ETC specified in this section.
   2. The Electrical Contractor shall supply a suitable and stable source of test power to the ETC at each test site. The ETC shall specify these requirements.
   3. The Electrical Contractor shall notify the ETC Company when equipment becomes available for electrical tests. Work shall be coordinated to expedite project scheduling.
   4. The Electrical Contractor shall clean all the electrical equipment prior to testing by the ETC.
   5. The ETC Company shall be responsible for implementing all final settings and adjustments on protective devices and electrical equipment in accordance with the Power System Protective Device Studies.
E. Any questions or concerns identified shall be promptly addressed to the Owner's Representative.

F. Any system, material, or workmanship which is found defective on the basis of electrical inspections and tests shall be reported directly to the Owner's Representative.

G. If a test reveals a fault or problem, the entire test will be repeated until the problem is corrected. Submit additional written test reports.

H. Maintain a written record of all tests, and upon completion of the project, assemble and certify a final test report. The field test reports shall be compiled, “stamped”, and signed by the site lead engineer.

I. Power systems protective device calibration

   1. Adjustments, settings and modifications
      a. The ETC shall calibrate necessary field settings, adjustments and minor modifications to conform to the coordination study without additional cost. (Examples of minor modifications are trip sizes within the same frame, the time curve characteristics of induction relays, ranges etc.)
         i. Adjust protective devices to the values provided in the coordination study.
         ii. Test the minimum pickup and delay, ground fault pickup and delay.
         iii. The trip characteristics, when adjusted to setting parameters, shall fall within the manufacturer’s published time-current characteristic tolerance.

   2. The ETC shall verify that the protective devices have been adjusted and set in accordance with the approved protective device study.

J. Acceptance criteria

   1. Each function and test shall be performed under conditions which simulate actual operating conditions as closely as possible.
      a. To that end the Contractor shall provide all necessary materials and equipment and temporary system voltages and currents to simulate fault conditions on the system being tested in order to prove and verify proper operation.
      b. At satisfactory completion of all verified tests, the building electrical system being tested shall be returned to the condition required by the contract documents as a complete and operational system.

   2. The ETC shall perform general inspections at the job site and shall also review the following:
      a. Assembly of the accessory equipment, and the interconnecting wiring for control circuits and fire alarm interface
      b. General inspection of the following: Appearance, finish, alignment of doors, covers and similar parts; quality of workmanship; possible shipping and other damage; missing, broken or incorrectly applied devices; loose or missing accessories, bushings or hardware; loose or broken wires; proper installation of all equipment; verify that shop drawings and instructions have been shipped with all equipment and are available.
c. Support of electrical equipment: Inspect and check all electrical equipment for support and seismic bracing.
d. Spare fuses: The ETC Engineer shall inspect and verify spare fuse inventory as specified by Division 16.

3. Testing requirements and procedures

a. The following equipment and systems shall be inspected and tested by the ETC per NETA, manufacturer's instructions, and additional requirements noted.
   i. Transformers
      (a) All dry type greater than 600 Volt
      (b) Dry type 600 Volt and below
         (1) All transformers greater than or equal to 167 KVA single-phase and 225 KVA 3-phase
      (c) All liquid-filled transformers.
      (d) Tests
         (1) Inspect for physical damage, proper installation, anchorage and grounding.
         (2) Verify transformer is supplied and connected in accordance with contract documents.
         (3) Verify that the transformer secondaries have a clockwise phase rotation sequence.
         (4) Adjust the transformer taps to the nominal system voltages per ANSI C84.1-1989.

   ii. Instrument transformers

   iii. Medium voltage vacuum and air circuit breakers

   iv. Cables

      (a) Medium voltage cable (greater than 600V)
         (1) Apply grounds for a time period adequate to drain all insulation-stored charge - minimum of 24 hours.
         (2) Field test D.C. voltages (kilovolts):

<table>
<thead>
<tr>
<th>Insulation Voltage Class</th>
<th>Acceptance Voltage</th>
<th>Maintenance Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Cable</td>
<td>Cable age &gt; 10 years</td>
</tr>
<tr>
<td>15kV AC</td>
<td>35kV DC</td>
<td>16kV DC</td>
</tr>
<tr>
<td>5kV AC</td>
<td>15kV DC</td>
<td>2.5kV DC, Megger for 10 minutes</td>
</tr>
</tbody>
</table>
*Prior to splicing new cable into existing, test existing cable at maintenance value. If acceptable, perform splicing, then test old and new together at the maintenance value.

v. AC and DC motors 10 hp and larger
vi. DC battery systems
vii. Surge arrestors
viii. Reactors
ix. Other utilization equipment
x. Switches (air and oil)
   (a) Verify correct wire bending radii at terminations per wire manufacturer’s recommendations and NEC.

xi. Circuit breakers
   (a) Low voltage power circuit breakers (all) and insulated case/molded case circuit breakers 400a and larger and all with adjustable instantaneous trip adjustments.

   (1) Calibrate and set all breaker settings per the Protective Device Coordination Study.

xii. Protective relays and devices
   (a) Modify NETA tests according to manufacturer’s recommended testing procedures.
   (b) Calibrate and set all relay settings according to the Protective Device Coordination Study.

xiii. Ground fault systems
   (a) Calibrate and set all ground fault settings according to the Protective Device Coordination Study.

xiv. Metering
   (a) Modify NETA tests according to manufacturer’s recommended testing procedures.
   (b) Calibrate and set all meter configuration settings.

   (1) Settings:
   - Set Vars to + to the load.
   - Remote programming enabled
   - Request the device address from the University and set it accordingly.
   - Setup PT and CT ratios, system voltage and all other programmable parameters to make the meter and its features fully functional.

xv. Emergency off switches
(a) Test all emergency off switches and verify shut down and reset of equipment.

xvi. Motor control
(a) Motor starters - medium and low voltage

xvii. Motor control centers
(a) Verify correct overload heaters are installed.

xviii. Variable frequency drives
(a) Electrical tests and inspections to be performed by the manufacturer
(b) Measure and document harmonics at main switchgear or a designated point of common coupling. Confirm measurements meet Division 15 requirements.

xix. Capacitors
(a) Verify that 97% power factor correction has been reached at full equipment load.

b. The following equipment shall be inspected and test by the manufacturer's authorized service representative in coordination with the ETC and the Contractor. Inspect and test according to NETA, the manufacturer's recommended procedures and the operational testing procedures described herein.

i. Spot or distributed network substations:
Special functional testing requirements are detailed below for power substations that are configured as spot or distributed networks. These procedures are based on the typical “Network Control” and “Network Control Power” schematic drawings shown in chapter 16N. Modify procedures as needed to suit the actual network protector system provided. Items a through c shall be completed before scheduling the testing procedure with the University detailed in Items d through dd.

(a) Complete the entire installation for the unit substation including the bus tie to the other two unit substations so the entire substation is functional.
(b) Set all breaker trip unit functions per the coordination study. Remember to configure the spot network relay.
(c) The testing agency shall complete all the required testing and calibration for the entire substation and associated equipment/devices. This includes breakers, relays, and other devices set according to the Short Circuit and Coordination study.
(d) Arrange for the following testing with the UW High Voltage Shop, Engineering Services and the UW Construction Manager/Coordinator. The network relay and/or switchgear manufacturer representative should be present to assist in the commissioning process. Only the original equipment manufacturer's authorized service representative shall perform
all testing associated with network protector relays. No exceptions to this requirement shall be permitted.

(e) The UW High Voltage Shop shall inspect the primary switch and unit substation for proper connection and verify phasing.

(f) Place the network Auto/Off/Manual selector switch into the off position.

(g) With the main and tie breaker open and racked out, close the primary switch to energize the transformer.

(h) The High Voltage Shop shall verify phasing, rotation and voltage at both the transformer and across the open tie breaker.

(i) Verify control voltage is present.

(j) Rack in the main breaker.

(k) Place the network Auto/Off/Manual selector switch into the manual mode.

(l) Make sure the 86 lock-out relay is reset.

(m) Close the main breaker with the breaker control switch. Check the bus and control voltage.

(n) Trip the main breaker with the breaker control switch. The main breaker should open and the breaker should recharge.

(o) Open the primary switch and discharge the main breaker spring.

(p) Place the network Auto/Off/Manual selector switch into the off position.

(q) Rack in and close the network tie breaker. Check the bus and control voltage.

(r) Place the network Auto/Off/Manual selector switch into the manual position. The main breaker should charge but not close.

(s) Attempt to close the main breaker with the breaker control switch. The breaker should not close since the primary switch is open.

(t) Place the network Auto/Off/Manual selector switch into the Auto position. The main breaker should not close since the primary switch is open.

(u) Close the primary switch. The main breaker should automatically reclose.

(v) Place the network protector Auto/Off/Manual selector switch into the manual mode.

(w) Trip the main breaker with the breaker control switch.

(x) With the main breaker NAC contact on the breaker control switch tripped (green flag), place the network Auto/Off/Manual selector switch into the auto mode. The main breaker should not reclose.

(y) Close the main breaker with the breaker control switch, resetting the NAC switch (red flag). The main breaker should automatically reclose.

(z) Trip the 86 lockout relay which should open the main breaker and lock it out.

(aa) Reset the 86 lockout relay. The main breaker should automatically reclose.

(bb) Open the primary switch. The main breaker should trip and recharge.

(cc) Close the primary switch. The main breaker should reclose.

(dd) Repeat the last two steps with the tie breaker open and also the network Auto/Off/Manual selector switch in the off and manual modes.
ii. Emergency systems
   
   (a) Emergency generator systems
   
   (1) Inspect and test per NETA and manufacturer’s recommended start-up and testing procedures.
   (2) Perform resistive and reactive load testing at .8 pf (lagging).
   (3) Test phase rotation to determine compatibility with load requirements.

   (b) Automatic transfer switches
   
   (1) Coordinate with Automatic Transfer Switches Section.
   (2) Verify clockwise phase rotation and in-phase transfer between the two sources of power.
   (3) Adjust all timers and other parameters as recommended by the manufacture and the Engineer. A set-up sheet of final parameter settings, which includes spare columns for future modifications, shall be provided inside the enclosure.
   (4) Test all the standard and optional features specified for the transfer switches.
   (5) Test load management contacts, both block transfer and load shed. Simulate a load-shed signal from the CMCS (Central Monitoring and Control System) for this purpose.

   (c) Uninterruptible power supplies

   c. The following equipment shall be inspected and tested by the Contractor. Coordinate activities with the manufacturer’s authorized service representatives and the ETC.

   i. General power system tests
   
   (a) Load balance tests: Check all panelboards for proper load balance between phase conductors, and make adjustments as necessary to bring unbalanced phases to within 15% of average load.
   (b) Motor tests: Check all motors for proper rotation and measure actual load current. Submit tabulation of motor currents for all motors 10 HP and larger after the HVAC system has been balanced.
   (c) Phase relationship tests: Check connections to all new and existing equipment for proper phase relationship. During such check, disconnect all devices which could be damaged by the application of voltage or reversed phase sequence.

   ii. Metal enclosed ducts
   
   (a) Inspect bus for physical damage and proper connection. Clean interior and insulators where applicable.
   (b) Inspect for proper bracing, suspension, alignment and enclosure grounding.
(c) Measure insulation resistance of each bus phase-to-phase and phase-to-ground (1 minute minimum).
(d) Inspect all accessible bus joints and cable connections by infrared scanner to detect loose or high-resistance connections and other circuit anomalies.

iii. Low voltage feeder and branch circuit conductors 4/0 and larger (600V and below)
   (a) Test for continuity of each circuit.
   (b) Test for grounds in each circuit; test shall consist of the physical examination of the installation to ensure that all required ground jumpers, devices, and appurtenances do exist and are mechanically firm.
   (c) Perform a 500 volt megohm meter test on each circuit between the conductor and ground. The insulation resistance shall not be less than 2 megohms for circuits under 115V, 6 megohms between conductor and ground on those circuits (115V-600V) with total single conductor length of 2500 feet and over, nor less than 8 megohms for those circuits (115V-600V) with single conductor length of less than 2500 feet. If conductor fails test, replace wiring or correct defect and retest.
   (d) Perform torque test for every conductor tested and terminated in an overcurrent device or bolted type connection; torque all connections per manufacturer’s recommendations and tabulate the results on a tabular form.

iv. Panelboards
   (a) Inspect for physical damage, proper installation, supports and grounding.
   (b) Verify that neutrals are grounded only at the main service.
   (c) Load balance tests: Checks all panelboards for proper load balance between phase conductors and make adjustments as necessary to bring unbalanced phases to within 15% of average load.

v. Grounding systems
   (a) Perform fall-of-potential test on main grounding electrode system per IEEE Standard No. 81. Maximum resistance to ground shall be less than 5 Ohms for commercial or industrial systems and less than 1 ohm for generating or transmission station grounds. If this resistance cannot be obtained with the ground system, notify UW Project Coordinator for further instruction.
   (b) Verify that neutrals are grounded only at the main service by removing the service neutral grounding conductor and meggering the neutral bus.
   (c) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system-neutral, and/or derived neutral points. Investigate resistance values, which exceed .5 ohm. If this resistance cannot be obtained with the ground system, notify UW Project Coordinator for further instruction.

vi. Convenience receptacles
(a) Receptacle polarity test: Randomly test one receptacle in each room or hallway installed or re-connected by this project. Test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot on neutral and hot open. For Hospital areas add retention (pull out) test of Ground Blade per NFPA99. Rewire receptacles as required.

(b) Ground-fault receptacle circuit interrupter tests: The Test Engineer shall test each receptacle or branch circuit breaker having ground-fault circuit protection to ensure that the ground-fault circuit interrupter will not operate when subjected to a ground-fault current of less than 4 milliamperes and will operate when subjected to a ground-fault current exceeding 6 milliamperes.

vii. Special systems

(a) Service column for operating rooms

(b) Test each electrical and communication device to insure proper connections. If device does not work, find the problem and correct it. This work shall include correcting wiring inside the patient service column. Demonstrate correct polarity and show that neutral to "hot" does not exceed 68 volts AC.

viii. Isolated power system for operating rooms

(a) After the installation of the isolated power system and equipotential grounding system has been completed, an independent testing agency with assistance from the Contractor shall perform the following tests in accordance with NFPA 56A.

(1) Measure the impedance (capacitive and resistive) to ground of all conductors with the connection between the line isolation monitor and reference grounding point open. Replace wiring that measures less than 500,000 ohms.

(2) Measure the potential difference and resistances between the isolated power panel ground bus and the grounding pole of each receptacle and the patient grounding point.

(3) Also measure the potential between the grounding pole of each one of the receptacles and each of the other receptacles. The potential difference shall not exceed 10 millivolts with the system both energized and not energized.

(b) Measure system voltage.

(c) Measure readings of ungrounded system components, including isolation transformer and line isolation monitor.

(d) Measure system leakage with line isolation monitor connected in circuit.

(e) Measure system leakage with surgery track light and film viewers energized.

ix. Equipotential grounding system for operating rooms
(a) After the equipotential grounding system has been installed and prior to the walls being enclosed, the Contractor shall perform the following tests:

1. Measure the potential difference between the grounding wire to the patient ground jack and any of the bonded exposed conductive surfaces. Correct bonding of any items with a reading over 100 millivolts.
2. Measure the resistance between the grounding wire to the patient ground jack and any of the bonded exposed conductive surfaces. Correct bonding of any items with a reading over 0.1 ohms.

(b) After the rooms are finished and all devices are installed, the equipment manufacturer with assistance from the Contractor shall perform the same tests described above, including any items that were not installed prior to the previous tests.

c) Record all test values and include them in the maintenance manual information. The tests shall be witnessed by the Electrical Engineer and the University's Representative. Schedule tests with Owner and Engineer at least one month prior to test date.

K. Labels

1. Upon completion of the inspection, calibration and testing, attach a label to all devices tested. These labels shall indicate the date tested, the ETC company name and tester's initials.

L. Retesting

1. Any fault in material or in any part of the installation revealed by these tests shall be investigated, replaced or repaired by the Contractor and the same test repeated by the ETC at Contractor's expense until no fault appears.

3.02 REPORTS

A. ETC shall prepare test reports on the systems tested. Include a copy of each test report in the Operation and Maintenance Manuals.

1. The ETC shall prepare test reports including the following:
   a. Summary of project
   b. Description of equipment tested
   c. Description of test
   d. Test results including retesting results
   e. Test dates
   f. Tester's name
   g. Witnesses (when required)
   h. Corrective work
   i. Acceptance criteria
   j. Conclusions and recommendations
k. Appendix, including appropriate test forms
G. ELECTRICAL - MV WIRE, CABLE AND TERMINATIONS

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project requirements in consultation with the Owner.

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

1. This section covers medium voltage (MV) cable and terminations for use in the University's primary and secondary power distribution systems.

1.02 WORK SCOPE

A. A site walk needs to be scheduled with the Electric Utility Manager to define a project's work scope.
B. Sections of the MV armored cable have reached the end of life and needs replacement.
C. Link boxes are being replaced with dead break elbows mounted on a junction box or cable hangers depending on safe working clearances.

1.03 QUALIFICATIONS

A. Approved manufacturers

1. Medium voltage 5 and 15kV wire and cables
   a. 5 and 15kV single conductor: Pirelli, Aetna, and Okonite
   b. 5 and 15kV armored cable: Pirelli, Aetna, and Okonite
      i. Service Wire for short lengths of interlock armored cable (< 500 feet)
   c. All other manufacturers shall be approved during the design prior to bidding.

1.04 RELATED SECTIONS

A. The work under this section is subject to requirements of the Contract Documents, including the General Conditions, Supplemental Conditions, and sections under Division 1 General Requirements.
B. Electrical Identification
C. Inspection, Calibration and Testing
1.05 REFERENCES

A. Applicable codes, standards, and references codes, regulations and standards

1. National Electrical Testing Association – NETA
3. National Electrical Code - NEC
4. AEIC CS6-96 (ethylene propylene rubber)
5. ICEA S-93-639 (ethylene propylene rubber)
6. IEEE STD 400-1991 (DC Testing)
7. IEEE STD 48
8. UL 1072 for physical requirements for the armor
9. UL 1008 – Automatic Transfer Switches
10. State and local codes and ordinances

1.06 COORDINATION

A. Coordinate Operations and Maintenance training times with the University.

1.07 SUBMITTALS

A. General

1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
2. Submit detailed maintenance manuals and drawings, which include catalog information indicating the complete electrical and mechanical characteristics.
3. Submit current manufacturer’s AEIC pre-qualification data.
4. Submit dimensioned cross-sectional drawings (manufacturer’s data sheets are acceptable).
5. Submit finished cable tests – Manufacturer’s Certified Test Reports showing compliance with ICEA S-68-516, Part 3, and UL 1072 for physical requirements of the armor and all AEIC final tests, including x-y plots of corona discharge for the actual cable furnished.
6. Submit pulling calculations and plan for each medium voltage cable length.
7. Submit data sheet on crimping tools to be used.
8. Submit for approval the résumés of the medium voltage cable splicers. Qualifications should include certification, recent work history on similar splice type and knowledge of the “Safety Standards for Electrical Workers” (WAC 296-45).

1.08 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
B. Operations and Maintenance Manuals shall include but not be limited to pull calculations and catalog information indicating complete electrical and mechanical characteristics.
C. Manufacturer’s Certified Test Reports
D. Manufacturer’s AEIC Pre-qualification Data
1.09 MEETINGS

A. Pre-installation conference
   1. The Contractor shall request a pre-installation conference with the University's Engineering Services and University's Physical Plant High Voltage Shop for projects with medium and high voltage work.

B. Attend meetings with the Owner and/or Owner's Representative as required to resolve any installation or functional problems.

C. Within 1 month after "Notice to Proceed," schedule a meeting with UW Representatives to review electrical identification requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. These cable and terminations specifications are in accord with the University's policy to construct permanent installations with long life, coupled with maximum reliability and safety. It is intended that the best available materials be used and new and better materials adopted as they become available and are approved by the University.

2.02 MEDIUM VOLTAGE WIRE AND CABLE

A. The following shall apply to both 5kV and 15kV medium voltage power conductors used as single conductors or assembled into 3/c armored cable:

   1. Single conductors

      a. Conductors: Class B stranded, concentric, soft or annealed copper per Part 2 of ICEA S-68-516
      b. Strand screen: Extruded semi-conducting thermosetting compound applied over the conductor. The material shall be compatible with the conductor metal, shall be uniformly and firmly bonded to the overlying insulation, and be free of stripping from the conductor.
      c. Insulation: High quality heat, moisture, ozone and corona resistant Ethylene Propylene Rubber (EPR) compound
         i. The insulation shall contrast in color with the strand screen and insulation shield per AEIC CS 6.
         ii. Insulation level shall be 133% (115 mils for 5KV, 220 mils for 15KV).
         iii. The minimum thickness of the insulation at any point shall not be less than 90% of the specified nominal thickness.
         iv. The insulation shall contain no more than 2% polyethylene.
      d. Insulation shield: Extruded semi-conducting thermosetting compound applied directly over the insulation. The material shall be compatible with the insulation and
overlying metallic shield. The insulation shield shall be clean and free of stripping from the insulation and comply with Paragraph D.1 of AEIC CS 6.

e. Manufacturing process: The strand screen, insulation, and insulation shield shall be applied with a triple-tandem process providing a virtual corona-free core. The EPR insulation system shall not be exposed to the atmosphere during manufacture.

f. Metallic shield and individual jacket: .005 inch thickness of copper tape helically applied over the insulation shield material with a 20% overlap, covered with an extruded PVC outer jacket meeting the requirements of ICEA S-68-516 Paragraph 4.4.10.

g. Identification: The following information shall be surface-printed on the overall jacket: Manufacturer's name, cable size, cable type, year of manufacture and voltage rating.

2. Armored cable

a. Single conductors: Per the section above. (Note: Individual PVC jacket shall be required for each single conductor).

b. Grounding conductors: Bare copper, stranded in accordance with ICEA S-68-516, Part 2. Minimum size shall be in accordance with UL 1072, Table 11A. (Note to designer: Provide a larger size, if required, to handle calculated fault current.)

   IMPORTANT: In the University of Washington primary distribution system the size of main primary feeders are 500 KCM. In instances where #2/0 cable is tapped from 500 KCM cable, to subfeed a facility or load, provide ground conductors in #2/0 cable equal to the ground conductor of 500KCM cable. Ground conductors shall be factory installed with the phase conductors and shall be an integral component of the cable. This is not an industry standard and shall be clearly indicated in the design documents. Supplemental grounding conductor external to the interlock armored cable is not acceptable by the AHJ.

c. Filler material: Non-hygroscopic material, fine fiber, completely filling center and peripheral interstices

d. Binder tape: Applied over assembly to provide a solid core

e. Armor: Galvanized steel or aluminum, interlocked armor in accordance with ICEA S-68-516, Part 4 and UL 1072, Part 25.11

f. Overall jacket: Polyvinyl Chloride (PVC) in accordance with ICEA S-68-516 paragraph 4.4.10. Industry standard color by voltage class (15kV cable – red; 5kV cable – yellow).

g. Identification: The following information shall be surface printed on the overall jacket: Manufacturer's name, cable size, cable type, year of manufacture and voltage rating.

h. Listings: Finished cable shall be UL listed as Type MC, MV-90 and "For CT USE."

i. Color for outer jacket shall be consistent with industry standards.

3. Cable rejection
a. Cable shall be subject to inspection by the University at delivery and installation and subject to rejection for shipping and/or installation damage including, but not limited to, jacket penetration, armor denting, or other indications that cable integrity has been compromised.
b. Hi-pot and Megger testing will not be the sole determining factor in the Owner accepting or rejecting damaged cable.

2.03 SPLICES AND TERMINATIONS

A. Medium voltage

1. Medium voltage connections and terminations (armored cable and single conductor) - Long barrel, 2-hole hydraulic crimp lugs, with Raychem "HVT" or 3M "Quick Term" series 5600 termination kits

2. Existing link box are to be replaced with MV junction boxes with deadbreak elbows. Grounding drain wires to be long enough that elbows can be removed and replaced without resplicing the connection.

3. Splices other than cold shrink are to be housed in a listed enclosure: OZ Gedney Series SPKJR, G&W #E74 or Adalet 3AS manufactured by PLM, with fittings to suit cable.

**IMPORTANT: Specifier to add Exact Requirements for Cable**

4. Fireproof any cables outside of cable tray with a non-asbestos liners.

5. Method of crimp termination for #8 awg and larger shall be performed with correctly sized hexacentric die only.

   a. Approved manufacturers: 3M, Elastimold; all other manufacturers shall be approved prior to bidding.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. General installation

1. Identification

   a. Reference section Electrical - Wire, Cable and Terminations

2. Qualification and Training

   a. Medium voltage cable work shall be performed by qualified and experienced personnel. Cable manufacturer's representative shall provide training and shall oversee the rigging, pulling, installation, and termination of medium voltage cable.

3. Installation

   a. The installation of cables shall be done with care to avoid damage.

      i. Cables showing damage after installation shall be replaced.
ii. Rollers and spools shall be used in adequate numbers for pulling in cables.
iii. The tension limitations, side wall pressure, and minimum bending radius as given by the cable manufacturer shall be observed.

b. Cable pulling
   i. In no case will strands be removed to attach pulling eyes.
   ii. Tension is limited to 1000 lbs. using basket grips.
   iii. Lubrication shall be as approved for the insulation and raceway material.
   iv. Prior to pulling, calculations of pulling tension and side wall pressure shall be submitted.
   v. A dynamometer shall be used and tension recorded for all MV pulls.
   vi. Use no mechanical means for pulling #8 and smaller AWG conductors.

c. Cable pulling setups and operations shall be witnessed by the University Physical Plant High Voltage Shop and Engineering Services.

d. Interlocked armor cable shall be pulled only when both the armor and conductors are gripped. Remove cable similarly.

e. All cable that leaves a tray shall be taped/wrapped with Scotch 77, MAC AP30, or Quelcor “Quelpyre” fireproofing tape.

B. Medium voltage cable terminations
   1. Phase mark each conductor, secure conductors adequately and observe cable bend radius limitations. University will identify the West Receiving Station phase rotation convention.
   2. System Phase Sequence is C-B-A.
   3. MV switch phase terminations shall be A-B-C left to right when facing the front of the switch.
   4. Junction box phase terminations are A-B-C left to right.
   5. Standard link box phase terminations are A-B-C left to right, top to bottom, front to back. Some existing link box phase terminations are not standard, especially on the 2.4kV normal and emergency power system.
   6. The Physical Plant Department High Voltage Shop will identify the phase designation of the existing primary distribution system conductors to which the Contractor is to make a connection.
      a. They will also check the Contractor's work to ensure the accuracy of the connections.
      b. The Contractor shall arrange with the University for the times when their services will be required, and under no circumstances shall the Contractor connect to the existing system without their knowledge.
      c. The proper connection of the wires and cables to other systems as specified is entirely the responsibility of the Contractor.
      d. In the event the connections cannot be made as specified, the Contractor shall make the necessary corrections at his own expense.
   7. Install cable terminations per manufacturer’s recommendations.
8. Medium voltage cable splices shall be made only when absolutely necessary. When necessary, splices shall be made only by personnel qualified and experienced in this type of work.

9. Each high voltage splice or connection shall be permanently labeled with the following information:
   a. Contract or project designation
   b. Contractor doing work
   c. Name of splicer and date

10. Do not score the conductor when stripping insulation and always pare or pencil when using a blade. Use of a stripping tool is preferable.

11. All terminations shall be secure and tightened in accordance with the manufacturer's recommendations.

C. Mounting and electrical connections
   1. In accordance with manufacturer's installation instructions.
   2. Coordinate remote control and annunciation with the University representatives.

D. Training
   1. Provide operation and maintenance training for two 2-hour sessions of on-site training for a total of 6 maintenance personnel.
   2. Include troubleshooting, repair and maintenance manuals for each participant.

E. Testing
   1. Provide factory field startup and testing services to assist the ETC (Electrical Testing Contractor) per Section Electrical - Inspection, Calibration and Testing.
H. ELECTRICAL - SHORT CIRCUIT AND COORDINATION STUDIES

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the owner. The requirements in the “Schedule” section here will impact other specification sections. The designer shall modify these specification sections and edit the “Related Sections” below accordingly.

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

1. The purpose of these studies is to assure all electrical equipment is correctly applied within industry and manufacturer’s ratings. This effort should minimize the damage and limit outages caused by any electrical failure and will assure proper personnel protection. These studies are required from the Contractor once the actual equipment being provided has been determined.

B. General

1. The Power System Protective Device Studies shall consist of one-line diagram(s), short circuit and coordination studies prepared for the specific electrical equipment, overcurrent devices, utilization equipment (NEC defined) and feeder lengths involved with this project. The study shall also include Arc Flash Analysis and Hazard/Risk categories for distribution points such as transformers, switchboards, panelboards, MCCs, VFDs, disconnect switches, etc.

2. Furnish labor, material and coordination with Engineering Services to accomplish the studies as specified in this section.

1.02 QUALIFICATIONS

A. Studies to be performed by or under the supervision, review, and approval of a professional Electrical Engineer holding a current license from the State of Washington.

B. Preapproved, subject to the Licensed PE requirements and the software analysis products specified in this section:

1. Eaton Technical Services
2. Electrotest Inc.
3. Power Systems Engineering
4. Siemens Technical Services
5. Western Electric Inc

1.03 RELATED SECTIONS

A. The work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplemental Conditions, and sections under Division 1 General Requirements.

B. Inspection, calibration & testing section

Note to the designer: Add the related sections’ references according to the requirements of the schedule section.

1.04 REFERENCES

A. Applicable codes, standards, and references:
   1. National Electrical Code – NEC
   2. Institute of Electrical and Electronic Engineers – IEEE
   3. American National Standards Institute – ANSI
   4. State and local codes and ordinances

1.05 COORDINATION

A. Coordinate with the electrical contractor and equipment vendors, as required, to determine the actual equipment to be furnished.

1.06 SUBMITTALS

A. General
   1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
   2. The studies shall be submitted stamped by a professional Electrical Engineer holding a current license from the State of Washington.

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

1.08 SCHEDULE

A. One purpose of these studies is to verify equipment ratings. Submit preliminary Short Circuit and Coordination Studies with the submittals for the protective devices, panelboards, switchboards and other electrical equipment.

Note to the designer: Coordinate the equipment submittal requirements in the appropriate specifications sections with the requirements noted above.
1.09 MEETINGS
A. Attend meetings with the Owner and/or Owner’s Representative as required to explain the results of the studies and to determine any corrective action that is required.

PART 2 – PRODUCTS

2.01 APPROVED SOFTWARE ANALYSIS TOOLS
A. The Short Circuit Study, Coordination Study, and Arc Flash Calculations shall be performed using the SKM Power Tools for Windows (PTW) software package, with no substitution:
B. SKM PTW software package used shall be the latest available releases.

PART 3 – EXECUTION

3.01 REQUIREMENTS
A. Perform Power System Protective Device studies.
B. The Contractor shall be responsible for gathering all field information and data needed for the protective device studies.

3.02 ONE-LINE DIAGRAM
A. Provide a one-line diagram from SKM PTW that shows the schematic wiring of the electrical distribution system. Include all electrical equipment and wiring to be protected by the protective devices installed under this project.
   1. Key nodes on the one line diagram shall be identified and referenced in the formal report. The one-line diagram shall include the following specific information:
      a. X/R ratios, utility contribution, and short circuit values (asymmetric and symmetric) at the bus of the main switchboard, and all downstream equipment containing overcurrent devices
      b. Breaker and fuse ratings
      c. Transformer KVA and voltage ratings, percent impedance, X/R ratios, and wiring connections
      d. Voltage at each bus
      e. Identifications of each bus
      f. Conduit material, feeder sizes, and length
      g. Calculated short circuit current
      h. Arc Flash hazard/risk categories

3.03 SHORT CIRCUIT STUDY
A. Assumptions for Short Circuit Study calculations:
* The three-phase fault level is a ½-cycle symmetrical value, which includes motor contribution and operation of all on-site generators. For purposes of calculating short circuits for devices with ½-cycle response, use this value as a steady-state quantity.

B. The study shall show fault currents available at key points in the system down to a fault current of 7,000A at 480V and 208V.

C. Determine the available 3-phase short circuit and ground fault currents at each bus and piece of equipment. Incorporate the motor contribution in determining the momentary and interrupting ratings of the protective devices.

D. Incorporate pertinent data and the rationale employed in developing the calculations into the introductory remarks of the study.

E. Present the data determined by the short circuit study in a table or report format. Include:
   1. Device identification
   2. Operating voltage
   3. Protective device
   4. Device rating
   5. Calculated 3-phase short circuit current (asymmetrical and symmetrical), and ground fault current

3.04 COORDINATION STUDY

A. Prepare coordination curves to determine the required settings of protective devices to assure selective coordination.
   1. Graphically illustrate, on a log-log scale, that adequate time separation is provided between existing and supplied series devices.
   2. Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices will be clearly depicted on one sheet.
   3. Utilize original SKM 8½ " x 11" #8511 paper for curve plotting.
   4. Derive settings for new protective devices in consideration of existing upstream protective device settings, and optimize system coordination in light of this constraint.
   5. Where the upstream device characteristics do not allow reasonable coordination with new equipment, identify the problem and the recommended resolution in a letter to the Project Manager prior to submitting the coordination study.
B. The following specific information shall also be shown on the coordination curves:
   1. Device identifications
   2. Settings and current transformer ratios for curves
   3. ANSI damage curves for each transformer
   4. Melting and clearing fuse curves
   5. Cable damage curves
   6. Transformer inrush points
   7. Maximum short-circuit cutoff point
   8. Simple one-line diagram for the portion of the distribution system that the coordination curves are depicting

C. Provide the SKM TCC report for each curve, labeled with the applicable curve number.

D. Develop a table to summarize the settings selected for the protective devices. Include in the table the following:
   1. Device identification
   2. Relay CT ratios, tap, time dial, and instantaneous pickup
   3. Circuit breaker sensor rating, long-time, short time, and instantaneous settings, and time bands
   4. Fuse rating and type
   5. Ground fault pickup and time delay
   6. Provide 2 test points for each protective device at levels that are compatible with commonly available test equipment, and the ratings of the protective device. Provide the input level and expected response time for each test point.

E. For substations with spot or distributed network protection provide calculations and settings to configure the network protection relays and prepare a report showing the engineered calculations.

3.05 Arc Flash Analysis and Hazard/Risk Category Calculation per NFPA 70E
   A. Perform Arc Flash Analysis and determine Hazard/Risk categories at distribution points per NFPA 70E and show them on one-line diagrams. Include both values for devices that provide a maintenance setting (e.g. RELT).

3.06 COORDINATION, SHORT CIRCUIT STUDY AND ARC FLASH ANALYSIS
   A. Analyze the short circuit calculations, and highlight any equipment that is determined to be underrated as specified or not coordinated. Propose approaches to effectively protect the underrated equipment. The Engineer will take major corrective modifications under advisement and the Contractor will be given further instructions.
   B. After developing the coordination curves, highlight areas lacking coordination. Present a technical evaluation with a discussion of the logical compromises for best coordination.
   C. Provide labels showing Arc Flash Hazard/Risk Categories to be affixed on all distribution points such as transformers, switchboards, MCCs, VFDs, disconnect switches, etc. See section 16AA, Electrical Identification, for a sample “Arc Flash Warning Label".
D. In addition to the O&M requirements, provide 1 hardcopy and 2 PDF electronic copies of the reports on CD. Also provide a CD of the SKM PTW studies for delivery to University of Washington Engineering Services. Provide the following immediately upon final completion of the Power Systems Protective Device Studies:

1. Copy of the Project One-line Diagram(s)
2. Coordination Study
3. Short Circuit Study
4. Arc Flash Analysis
5. A cross-reference index of the electronic file names on these disks or CDs to the specific pieces of equipment or systems.
I. DRY-TYPE, MEDIUM-VOLTAGE TRANSFORMERS

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project needs in consultation with the Owner and in accordance with the attached design information section.

PART 1 - GENERAL

1.01 BASIS OF DESIGN

A. Specification covers dry type transformers, with primary voltage above 600 V, For use as shown on plans

1.02 REFERENCE STANDARDS

A. ANSI C57.12.50 - Requirements for Dry-Type Distribution Transformers, 1-500 kVA 1-phase and 15-500 kVA 3-phase, with high voltage 601 - 34,500 V, low voltage 120-1000 V
B. ANSI C57.12.51 - Dry-Type Power Transformers 501 kVA and Larger, 3-Phase with High-Voltage 601 to 34 500 V, Low-Voltage 208Y/120 to 4160 V, Requirements for Ventilated
C. ANSI C57.12.55 - Dry-Type Transformers in Unit Installations, Including Unit Substations - Conformance Standard
D. ANSI C57.12.70 - Terminal Markings and Connections for Distribution and Power Transformers
E. IEEE C57.12.01 - General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings
F. NEMA ST20- Dry Type Transformers for General Applications
G. UL 1561 - Dry Type General Purpose and Power Transformers

1.03 SUBMITTALS

A. Submit Shop Drawings for equipment provided under this Section.
B. Acoustical Sound and Vibration Test Data
   1. Acoustical sound and vibration test data on manufactured unit.
      a. Test data sheets shall be submitted for review and approval by Owner and Architect/Engineer prior to shipment to job site.
C. Current Manufacturer's AEIC pre-qualification
PART 2 - PRODUCTS

2.01 MANUFACTURERS
   A. Acceptable Manufacturers: ABB, General Electric, Square D, Siemens, Eaton
   B. Approved equal.

2.02 RATINGS AND STANDARDS COMPLIANCE
   A. Show ratings and Impedance of transformer on drawings. Where impedance is not specified
   elsewhere provide 7% impedance for transformers in three transformer networks and 5.75%
   for non-networked transformers.
   B. Ventilated dry type transformers shall comply with ANSI 57.12.51

2.03 CONSTRUCTION
   A. Refer to drawings for cooling transformer type.
   B. Transformer shall be cooled by natural air and forced air convection (AA/FA).
      1. Units shall include fans to increase kVA rating by 33%
      2. Fan motors shall be 120 V with individual fusing.
      3. Temperature monitor and fan control unit includes:
         a. Temperature monitor with digital readout.
         b. GREEN- power on, YELLOW- fan on, RED- high temperature indicating lights.
         c. Audible high temperature alarm with alarm silence pushbutton.
         d. Maximum temperature memory with read and reset switch.
         e. Auto/manual fan control switch.
         f. System test switch.
         g. Auxiliary alarm contact for remote control and temperature monitoring.
         h. Acceptable manufacturer: Temptrol
      4. Temperature sensing in each coil.
      5. Sequence of Operation
         a. Transformer operating below natural air convection cooling (M) rating.
         b. GREEN light is activated
         c. Temperature rises to above natural air convection cooling (M) rating
         d. Relay is energized, fans and YELLOW light activate.
         e. Temperature rises to higher set point, relay energizes and audible alarm, RED light,
            and circuit for remote alarms activates.
      6. Control power shall be provided from control power transformer self-contained in
         equipment.
      7. Emergency Unit Substation transformers shall be pre-wired for future fan cooling,
         including RTD’s or thermocouples embedded in the windings for temperature control.
2.04 INSULATION TYPE VPI

A. Electrical Insulation
   1. Class H Insulation system shall be rated 220°C.
   2. Temperature rise based on a 30°C ambient with a maximum 40°C.
   3. Insulation shall be inorganic materials such as porcelain, glass fiber, electrical grade glass polyester, or Nomex.
   4. Coil assembly shall be Vacuum Pressure Impregnated (VPI) polyester.
   5. Transformer shall be:
      a. Designed for temperature rise of 150°C and shall be capable of operating at 33% above base nameplate kVA capacity continuously.
      b. Designed to meet sound level standards for dry-type transformers.
   6. Basic Impulse Insulation Level: 95kV for 15kV; 60 BIL for 5kV (emergency system); 30kV for 600V and below.

2.05 ENERGY EFFICIENCY

A. Minimum 98% efficiency or as required by Department of Energy minimum transformer efficiency requirements (CFR 43192 & DOE 78FR23335), whichever is greater.

2.06 CORE AND COIL

A. Coil:
   1. Windings shall be copper.

B. Core:
   1. Constructed of high grade, grain oriented, non-aging silicon steel.

2.07 TAPS

A. Taps:
   1. Rigidly support
   2. Mark for connections
   3. Accessible from front or back by panel removal
   4. Four 2 Y.% full capacity taps; two above and two below rated voltage.

2.08 ENCLOSURES

A. Transformer enclosure shall:
   1. Be constructed of 12 ga sheet steel.
   2. Be equipped with removable panels for access to core and coils.
   3. Include front and rear panels with ventilated grills.
   4. Include rubber isolation pads to isolate core from case. There shall be no metal-to-metal contact.
5. Base suitable for skidding in all directions.

B. Finish:
   1. Transformer enclosure and rails shall be finished with manufacturer's standard finish.
   2. Outdoor transformers shall have outdoor paint finish.

C. Ventilation Openings - Louvered or fine mesh screened. Punched holes are unacceptable to
   guard against insertion of foreign objects.

2.09 NAMEPLATE

A. Nameplates shall be:
   1. Secured to transformer enclosure with screws.
   2. Diagrammatic nameplate listing all information as required by NEMA standards.

B. Transformer:
   1. Transformer shall have nameplate with:
      a. Manufacturer's name and drawing number.
      b. Transformer identification tag as indicated on drawings
      c. Electrical connection diagram
      d. Primary and secondary voltage rating
      e. kVA rating
      f. Basic Impulse Level

C. Doors:
   1. Provide external doors and hinged bolted panels with "Caution - High Voltage - Keep
      Out" signs.

D. Submit identification to Owner/Architect/Engineer for approval.

2.10 ACCESSORIES

A. Transformer shall include:
   1. Provisions for lifting and jacking
   2. Removable panel for access for de-energized tap changing
   3. Two ground pads using Salisbury ground ball studs.
   4. A continuous 1/4" x 2" ground bus for connection to adjacent compartment's
      switchgear.

2.11 TERMINAL COMPARTMENTS

A. Transformer shall include HV terminal compartment and LV terminal compartment.
   1. Air filled primary terminal chamber adequately sized stress cone termination of 3 to 6
      single conductors as indicated.
B. Connections between:
   1. Primary device and transformer shall be bus.
   2. Transformer and secondary shall be Bus.
   3. Connections between the transformer and the switchgear shall be provided by the switchgear manufacturer.

C. Secondary neutral connection shall be brought out for bonding to ground bar.
   1. Provide fully insulated secondary neutral bushing (externally groundable) to permit the use at a neutral conductor or CT or GF sensing.

D. Provide removable link between neutral point and ground bar.

E. Distribution class surge arresters, rated at 15kV, located in HV terminal chamber.

F. Terminal markings shall be provided on the transformer terminals and shall clearly identify each terminal when doors or covers are opened.
   1. Transformers will have high voltage (primary) terminal markings:
      a. "H1" to "N' Phase
      b. "H2" to "C" Phase
      c. "H3" to "B" Phase
   2. Low voltage switchgear normally connected to the building power service transformers will be constructed in accordance with industry standards and will have their buses identified "1", "2", "3", "N". Transformers will have low voltage (secondary) terminal markings "X1", "X2", "X3", "XO" from left to right or top to bottom when facing the low voltage terminals and the switchgear shall be as follows:
      a. "X1" to "1" (BUS)
      b. "X2" to "2" (BUS)
      c. "X3" to "3" (BUS)
   3. Noted: transformer connections as indicated above results in a rotation sequence at the low voltage switchgear of "1", "2", "3".

2.12 QUALITY ASSURANCE
A. Transformers to be of the highest quality manufactured by a firm that has manufactured such apparatus for at least 25 years.

2.13 VIBRATION ISOLATION
A. Mounting type - Unit DNP (Double Neoprene Pad): Neoprene pad isolators shall be formed by two layers of 1/4-inch to 5/6-inch thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plates. These layers shall be permanently adhered together.
   1. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer’s recommended range.
   2. Provide steel top plate equal to the size of the pad. This is provided to transfer the weight of the supported unit to the pads.
3. Acceptable manufacturers: Amber/Booth
   a. Korfund Dynamics
   b. Mason Industries
   c. Peabody Noise Control
   d. Vibration Mountings Control
   e. Kinetics Noise Control

B. Provide vibration control devices, materials and related items. Perform all work as specified in this section to provide complete vibration isolation systems in proper working order.
   1. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.
   2. Size isolators to meet the specified loading requirements.
   3. Should equipment cause excessive noise or vibrations, the Contractor shall be responsible for remedial work required reducing noise and vibration levels. "Excessive" is defined as exceeding the manufacturer's specifications for the unit in question.
   4. Upon completion of the work, the Owner's Representative shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed. This work shall be done before vibration isolation systems are accepted.