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PREFERRED VENDORS AND PRODUCTS.....Appendix

Electrical

Central Utilities Systems

A. General Requirements

Basis of Design

This section applies to the general electrical requirements for all electrical work.

1. The majority of University construction is for permanent installation. Design electrical systems for a minimum anticipated 30 to 40-year life span before requiring major repairs or replacements. Exceptions to this requirement shall be discussed and agreed upon with Engineering Services during the programming phase. Such agreed-upon exceptions shall be clearly stated in the Technical Program.
2. Facility design standards can vary for branch campus and off-site facilities. Review these projects with Engineering Services to determine modifications to the Facilities Design Standard as appropriate. State these approved modifications in the Technical Program.
3. It is the intent of the University of Washington to minimize construction cost by fostering competitive bidding. If the designer feels that one or more of the provisions of this design standard arbitrarily eliminate an otherwise qualified manufacturer from bidding the project, suggest and review changes to the appropriate sections with Engineering Services. This may result in a one-time change or in a permanent revision to the design standard.
4. Where a detailed analysis of the program reveals an inadequate budget to provide the appropriate system design, notify the Project Manager and Engineering Services, in writing, of the budget deficiency, the recommended system and its cost, and the alternatives if a budget revision is not provided.
5. The impact of long equipment delivery time and the advantages of obtaining a locally manufactured product shall be factored into the project cost estimate and schedule.
6. The location of equipment that produces noise, vibrations and exhaust and the use of products or processes that create hazardous or offensive noise or fumes may be restricted.
7. Coordinate with Engineering Services the design of special systems (unique shielded rooms, research and diagnostic equipment, and other equipment and designs not specifically covered by the design standard.)

Inter-discipline Coordination

1. The Electrical Engineer shall work closely with other design team members to coordinate the design and to ensure that the space planning adequately accommodates the building electrical infrastructure. The electrical, mechanical and structural space requirements will necessitate changes to the floor plans, building sections and exterior elevations, if not properly taken into consideration from the onset of design.

2. Intersystem connection and wiring requirements need to be carefully coordinated between the various disciplines. Special attention needs to be given to the various life safety system components.
3. Coordinate with the Architect on the waterproofing of the main electrical rooms.
4. Coordinate with the Structural Engineer for the design of reinforced concrete housekeeping pad. Secure to structural slab.
5. Coordinate with the Civil Engineer so that exterior raceways and exterior vaults do not drain into a building.

Reference Plans and Specifications

1. Extensive operational drawings of the primary electrical system, fire alarm, clock and bell systems are available. Unlike other record drawings, these drawings are not available from the Records Vault since they are being updated on a continuing basis by Campus Operations. The latest version of these drawings can be obtained from Engineering Services.
2. Several standard specifications with specific language about the University requirements are included in the design standard. Spare parts inventories, prior experiences of the University, and staff training on the operation and maintenance of sophisticated equipment may restrict the list of suppliers to three or less, even though more suppliers with similar equipment may exist. Consultant's standard practices on approved manufacturers, suppliers, systems and equipment may not be appropriate for use on University projects.

Operational Constraints

1. In remodel and renovation projects and for taps into existing feeders, shutdown of feeders and services may be necessary. These shutdowns may have to occur after normal working hours to prevent interruption of critical operations. All shutdowns must be carefully coordinated with the University and can take several weeks of planning so all affected departments can plan operations around the outage. Temporary power may be necessary to maintain service to critical loads in hospital, health care, and laboratory areas, and to refrigeration equipment. Delays in the construction schedule due to outage coordination shall be accounted for in the construction estimate and noted in specifications or drawings.
2. General use buildings are operated to match occupancy and are normally shut down during nights (10pm to 6am), weekends, and holidays. Libraries usually have extended schedules. Health Science and laboratory buildings usually run continuously to maintain a safe working environment.
3. Design documents and details for the installation of devices and/or equipment in spaces that are complicated to access for maintenance, (i.e. atria, high ceiling areas, confined spaces, etc), shall include a "maintenance access plan". ES staff and UW shops responsible for maintenance and repair operations in such spaces shall review and approve the plan.

Construction Power

The point of service for construction power can be limited, especially where bulk power is required. The Engineer shall determine the construction power requirements and work with Engineering Services to identify the anticipated point of service. The Consultant shall specify that the Contractor

provide and maintain an electrical construction power system for all needs, including power for the construction trailers. The Contractor shall provide metering for all construction power tap points. The Contractor shall be responsible for the connection to and removal of their equipment from the University's system.

Renovation and Demolition

1. Renovation projects must include the evaluation of the existing systems including variances from current codes, system deficiencies, space limitations and available spare capacity. All design team disciplines shall participate in this evaluation jointly to develop innovative remodel concepts and solutions.
2. In general, remove abandoned equipment, raceways, and conductors. Electrical design shall address correction of existing electrical problems and removing abandoned equipment while maintaining the operation of the building. Define the reuse of equipment where appropriate.
3. Identify the cost and scope for the removal, remediation, and disposal of hazardous materials (PCB ballasts, PCB transformers, PCB floor contamination, lead containing materials, asbestos, etc.)

B. Design Criteria

Programming

Provide equipment access pathways large enough to allow for the removal of transformers and other large pieces of equipment. Identify these areas on the design drawings.

Include an evaluation for building system renovation projects which describes the condition of the building systems, variances from present codes, and identifies spare system capacity or system deficiencies and opportunities for improving energy efficiency. The design team's mechanical, electrical, civil, structural, and architectural disciplines participate jointly in this evaluation.

Design Criteria

1. Provide the basis of design including design parameters and analyses for the following:
 - a. Connection to existing utility distribution systems, including capacity and location,
 - b. Temporary construction service,
 - c. Distribution concepts,
 - d. Load calculations for campus utilities,
 - e. Seismic bracing for electrical equipment,
 - f. Special systems design (research and diagnostic equipment, and other equipment and designs not specifically covered by the FDS),
 - g. Control systems and equipment monitoring,
 - h. Occupancy, hours, and degree of activity,
 - i. Internal loads,
 - j. Special loads,
 - k. Code requirements and impact on criteria,
 - l. Noise criteria,
 - m. Building energy consumption and energy source,
 - n. Life cycle cost analysis for electrical systems,
 - o. Sustainability,
 - p. Maintainability,
 - q. Redundancy,
 - r. Future Capacity,
 - s. Standby Power,
 - t. Fire and Life Safety,
 - u. Review liquid infiltration issues for: exterior site penetrations; floor finishes above main electrical rooms and risers.
2. Design systems and components with maximum reliability, maximum flexibility, and minimum operation and maintenance cost. Give full consideration for future system alterations with a minimum of system shutdowns. Accomplish preventive maintenance without a major building shutdown. Maintenance accessibility is very important. Meet current regulations for worker safety, including fall protection.

3. Since laboratory buildings need periodic renovation to keep up with changing technology, divide the building up into lab modules.
4. Coordinate electrical equipment located on the roof with the Architect. Minimize the number of roof penetrations.
5. Provide an acceptable means of accessing major equipment that needs to be maintained on a regular basis without the use of a portable ladder.
6. Provide access platform for shafts.
7. Mount main service equipment (e.g. transformer, free standing switchboards) on a concrete pad secured to structural slab. Size concrete pads larger than equipment. Coordinate with Structural Engineer for final design.
8. See Architectural Finishes section for coating of floors above electrical rooms.
9. Coordinate with architectural and structural for location and installation.

Inter-discipline Coordination

1. Coordinate the electrical work with other disciplines to define the work and responsibilities of the Electrical Contractor. Because of the space taken up by the mechanical equipment, coordinate the required infrastructure with all elements of the building to include architectural, structural and mechanical. In many cases, the mechanical and electrical system space requirements necessitate changes to the floor plans, building sections, and exterior elevations, if not properly coordinated at the onset.
2. Align electrical risers to minimize offsets.
3. Coordinate between the Mechanical Engineer and Electrical Engineer for equipment motors, motor starters, disconnect switches, thermal overload switches, variable frequency drives, mechanical controls, and grounding for all mechanical equipment including AHUs, exhaust fans, and pumps.

Operational Constraints

1. Sustainability, operability, and maintainability are key elements in the evaluation of the Technical Program and Schematic Design. General use buildings are operated to match occupancy and are normally shut down during nights (10pm to 6am), weekends, and holidays. Libraries usually have extended schedules. Laboratory buildings normally run continuously to maintain a safe working environment 24 hours per day. Evaluate on a building-by-building basis to allow a more efficient operation.
2. In remodel or renovation projects, shutdowns of existing utilities and services may be necessary. These shutdowns may have to occur after normal working hours to prevent interruption of critical operations. Temporary utilities may be necessary to maintain service to critical loads in laboratories and hospital health care areas and to refrigeration equipment.
3. Locate equipment and accessories above ceilings such that they can be readily accessed within arm's reach by a person standing no higher than the second highest step on a stepladder of a height that fits below the ceiling. Coordinate ladder placement to avoid interference from casework, lab benches, sinks, adjacent walls, or lab equipment. Give consideration to ceiling tiles immovable due to sprinkler heads, light fixtures, or other ceiling mounted devices.

Construction Requirements

1. Include a statement in the specifications that all components of the electrical system must be kept clean and dry as manufactured, delivered, stored and installed before energization.

Renovation and Demolition

1. The abandonment of existing equipment and material in place is not acceptable. Conserve space as much as possible.
2. The correction of existing electrical problems and removal of abandoned equipment, while maintaining the operation of the building, all need to be addressed in the contract documents.

C. Primary Distribution

Basis of Design

This section applies to the design relating to connections to the Seattle campus primary electrical distribution systems.

Background Information

1. The power system serving the Seattle campus is owned and operated by the University. The University effectively runs its own electrical utility. The systems are operated and maintained by the Campus Operations High Voltage Electric Shop.
2. The University's normal power primary distribution is a 13.8 kV, 3-phase, 3-wire, low resistance grounded wye system. All new services will be connected to this system.
3. The University has a campus emergency and standby power system. Refer to the Electrical - Emergency Systems section for detailed information.
4. The University receives power from Seattle City Light (SCL) at two locations on campus. The utility **"points of service"** are located at the secondary connection to the SCL transformers. Four SCL feeders and transformers serve the University's West Receiving Station at 15th NE and Pacific St. One SCL feeder and transformer serves the University's East Receiving Station at the Power Plant. Interties connect the two stations and are switched to regulate power flow as required. A 6MW-extraction steam turbine in the Power Plant provides some co-generation. The amount varies with the campus steam load.
5. Normal and emergency power is distributed from the receiving stations through tunnels, utilidors and ductbanks. 500kcm metal-clad, interlocked armored cables feed power throughout the campus. #2/0 metal-clad, interlocked armored cable taps in manholes extend service into the buildings and padmount equipment. Relays at the receiving stations provide fault and overload protection for the 500kcm cable systems but only fault protection for the #2/0 cables. Fuses at the building disconnect switches provide overload protection for these #2/0 cables.
6. Equipment and conductors from the **"points of service"** to individual building secondary main breakers are designated as **"service conductors"** and include primary fused disconnect switches, service transformers, and secondary conductors to the secondary main breakers.
7. The building transformer secondary main breaker shall be designated as **"service disconnect"** and **"service overcurrent protection"**.
8. The Consultant shall coordinate all field design investigative work around the medium voltage systems and equipment with the High Electric Shop Lead or Supervisor. Field visits may require that a high voltage worker accompanying the Engineer.

Design Criteria

1. Medium voltage cable systems are standardized at 500kcm and #2/0. Code sized conductors can be used downstream of fused load interrupter switches and motor starters. Provide a minimum #2 ground conductor (regardless of the size of the phase conductors),

galvanized steel interlocked armor, and a PVC outer jacket to form a complete assembly. The ground conductor size is based on the 500kCM feeder size and the relays being set to protect 500kCM cables for fault protection. **Note that this is a non-standard ground wire size for 2/0 cable assemblies.** The Authority Having Jurisdiction (AHJ) may allow for a separate ground conductor to run parallel and external to the cable assembly so that industry standard cable can be specified. AHJ approval would be required.

2. For typical Utility Tunnel details, refer to the following Standard Drawings in the "Utility Tunnels, Trenches, and Manholes".
 - a. Drawing – Utility Tunnel Section
 - b. Drawing – Utility Trench Section
 - c. Drawing – Utility Tunnel Manhole Plan
 - d. Drawing – Utility Tunnel Electrical Tray Bracket Detail
3. Service conductor ductbanks shall be concrete encased and provided with spare cells for future services or cable replacements. Consider ductbank conductor derating per NEC when sizing the conductors and raceways. For these purposes, conductors larger than the University standard sizes may be required. For example, where 500kcm feeders need to be routed through a ductbank to reach their destination, they may have to be sized to 750kcm in order to retain the power delivery capacity of the feeder.
4. The use of padmount equipment is limited to locations where aesthetics allow. A buried vault to hold the transformer and associated equipment may be required. Generally, locate equipment within building electrical vaults or rooms.
5. Cables are generally subject to ambient temperatures of -20° to +40° C (0 to 105° F).
6. Conduits for medium voltage installations are rigid steel in buildings and street crossings; for direct buried or concrete encased applications, schedule 80 PVC may be used. Medium voltage cable shall not be directly buried.
7. Conduits for primary medium voltage distribution trunks (500 kcm cable) shall be 5" diameter minimum. Larger conduit may be required to facilitate cable pulls for long runs and multiple bends. Conduits for MV cable downstream of load interrupter switches and MV motor starters (#2/0 cable) shall be sized per code and cable pulling requirements.
8. Bends for 5-inch conduit used for primary medium voltage distribution trunks (500 kcm cable) shall have 5-foot radius minimum, to facilitate cable pulling operations. Radii for bends of smaller diameter conduit for MV cable downstream of load interrupter switches and MV motor starters (#2/0 cable) shall be per code and cable pulling requirements.
9. Termination and pulling vaults for medium voltage distribution shall be 7'Dx10'Wx10'L minimum to allow installation of MV load break elbows for taps to future facilities. Installation of smaller vaults shall not be allowed unless coordinated and approved in writing by UW Engineering Services.
10. Grounding systems shall be provided for all primary distribution ductbanks, utility tunnels, manholes, pulling vaults, transformer pads, switch pads, etc.
11. For future projects in the utility tunnels, an exposed and accessible personnel safety ground conductor shall be installed along tunnel lengths. Personnel safety ground conductor shall be 5000 kcm minimum and shall be installed such that they are readily accessible anywhere in the tunnel.

Submittals

1. Provide standard industry submittal requirements. In addition, comply with requirements specified in related sections.

Products, Materials and Equipment

1. Refer to the requirements specified in individual Electrical sections.

Installation, Fabrication and Construction

1. Cable and wire procurement, especially for short lengths of interlock armored cable, can take additional time. The Consultant shall include fair warning to the Contractor in the specifications.
2. Cable trays are used in tunnels, manholes, and elsewhere for carrying utility cables. For service reliability and safety, place only one high voltage cable in any individual cable tray unless otherwise directed. Cable trays, in general, shall be sized 9 inches wide in tunnels and 12 inches wide in manholes and shall include fire-resistant tray liners. Tray liners shall be non-asbestos type and shall be marked as such. Apply fireproof tape to cables installed outside of the cable trays.
3. In special cases, with prior written approval by UW Engineering Services, two cables may be routed in one cable tray. In such case, provide a tray-dividing barrier. The barrier shall be at least as tall as the armored cable diameter and securely fastened to the tray.
4. Do not use cable link boxes for new medium voltage splices, connections, and taps. (Cable link boxes are being phased out from the primary distribution system). Utilize cable junction boxes.
5. Medium voltage cable splices and connections are often placed in tunnels and manholes open to non-electrical workers. This requires that splices have protective covers and junction boxes have protective cages. The Consultant shall investigate and work with Engineering Services in designing appropriate worker protection barriers.
6. Size junction boxes and electrical vaults for terminations to allow future expansion of the cable system.
7. Splices may be placed in cable tray or supported on structure walls.

D. Electrical Meter and SCADA System

Basis of Design

This section applies to the requirements for both the Design Engineer and the Contractor.

Background Information

The Seattle campus collects metering and Supervisory Control and Data Acquisition System (SCADA) information

Design Criteria

Consultant needs to:

1. Review work scope with Engineering Services and Campus Utilities & Operations so a draft connection diagram can be submitted.
2. Work with potential equipment suppliers to verify how data will be posted on the UW VPN.
3. Reserve fees for UW Designated System Integrator.

Submittals

Coordinate with all the trades and disciplines involved, including (at a minimum) field installers of metering equipment, MV switches, transformers, and transfer switches.

Products, Materials and Equipment

Refer to this section's [standard specifications](#).

Installation, Fabrication and Construction

Requirements

1. General installation
 - a. Identification
 - i. Reference section 26 05 53 Identification
 - b. Installation
 - i. Only personnel qualified and experienced in this type of work shall make connections.
 - ii. The installation of meters shall be done with care to avoid damage.
 - (a) Meters showing damage after installation shall be replaced.
 - (b) Metering cabinets hung improperly shall be properly secured and all paint scratches shall be touched up.

- iii. Each meter shall have dedicated CAT5E communication cable installed to connect the meter to the facility network.
 - iv. Meters shall be installed such that the display is no higher than 72" above the floor.
- c. System Phase Sequence is C-B-A.
- d. Campus Utilities & Operations and Systems Integrator will check the Contractor's work to ensure the accuracy of the connections.
 - i. The Contractor to 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.
 - ii. The proper connection of the wires and cables to other systems as specified is entirely the responsibility of the Contractor.
 - iii. In the event the connections cannot be made as specified, the Contractor shall make the necessary corrections at his own expense.
- e. Install meters and SCADA i/o per manufacturer's recommendations.
- 2. Mounting and electrical connections
 - a. In accordance with manufacturer's installation instructions.
 - b. Install a dedicated 120V circuit from panelboard to provide power to the electrical meter in a dedicated RGC/IMC. (if required)
- 3. UL Listing
 - a. The Contractor shall ensure that the metering and SCADA installations are UL Listed.
- 4. SCADA Integration



E. Automatic Transfer Switches (ATS)

Basis of Design

This section applies to the design and installation relating to automatic transfer switches (ATS).

For the Automatic Transfer Switches (ATS) [Standard Specifications click here](#).

Design Criteria

1. Clearly indicate in the drawings and specifications whether the PNP, NPNP and/or BIS style switches are required. Eliminate sections of the attached standard specifications as required.
 - a. Specify Non-Programmed Neutral Position ("NPNP") for NEC 517 and NEC 700 emergency systems.
 - b. Specify Programmed Neutral Position ("PNP") for NEC 701 and NEC 702 legally required and optional standby systems and for systems that contain significant motor loads that would benefit from the neutral position for motor run down prior to restart.
 - c. Specify Bypass Isolation Switch (BIS) for all Medical Center applications and Health Sciences and major research lab applications that cannot tolerate prolonged shutdowns of the emergency system for maintenance. BIS is typically required where critical client equipment and systems are connected to the emergency system. Examples include freezers, bio-safety cabinets, life sustaining processes like pumped water to fish tanks, systems providing protection of facilities and personnel from environmental hazards, and equipment protecting facilities from damage, e.g. sanitary lift stations and sump pumps.
 - d. Specify CMCS integration for the University of Washington Medical Center.
2. Clearly indicate in the drawings and specifications whether CMCS monitoring and control provisions are required. Eliminate the appropriate sections of the attached standard specifications if the CMCS features are not required.
 - a. Seattle Campus: No new or renovated buildings outside the University of Washington Medical Center (UWMC) will be added to the CMCS System. The UWMC transfer switches will be integrated into the CMCS System.
 - b. Other UW Campuses and outlying facilities: CMCS monitoring and control is not required. Consult with UW Engineering Services to determine what, if any, site specific load management, monitoring and control functionality is required.
 - c. For transfer switches integrated into the CMCS system, coordinate with switchgear specifications to provide contacts for emergency feeder breaker position and emergency breaker truck position.

Submittals

1. Provide standard industry submittal requirements.
2. Refer to Automatic Transfer Switches standard specifications.

Related Sections

1. Building Systems
2. Emergency Systems

Products, Material and Equipment

1. Russelectric, no exception:
 - a. UW Class E1 and E2 emergency services.
 - b. Bypass/Isolation (BIS) style transfer switches.
2. Russelectric and other manufactures pre-approved by Engineering Services:
 - a. UW Class E3 and E4 emergency services.
 - b. Outlying UW Campuses, and other remote facilities.
 - c. Bypass/isolation (BIS) not required.
 - d. For each project, transfer switches shall be of the same manufacturer.
3. Circuit breaker style transfer switches are not acceptable.

Installation, Fabrication and Construction

Refer to Automatic Transfer Switches standard specifications.

F. AUTOMATIC TRANSFER SWITCHES – STANDARD SPECS

STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. 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 standard 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 01 **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
 - 4. National Fire Protection Association – NFPA
 - 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-to-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).
9. Four-position selector switch with "Manual", "Off", "Auto", "Test" positions
 - 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 ATs. (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 removing 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](#).

G. Medium Voltage Switchgear

Basis of Design

This section applies to the design and selection of medium voltage switchgear, primarily for use in substations.

Design Criteria

1. 13.8kV equipment shall be 15kV class, 4.16kV and 2.4kV equipment shall be 5kV class.
2. Equipment must match existing campus switchgear used in similar applications.
3. Stacked cubicles shall have cable entrances arranged to allow independent operating clearances for all devices and connecting cables, e.g. offset cable entrances and chimneys in termination compartments.
4. Place control wiring in raceways where possible. Where supported with tie wraps, the ties shall be bolted or screwed to their compartment wall. Adhesive supports are not acceptable.
5. The enclosures shall have hinged padlockable metal doors on the front and rear of each cubicle (separate doors for upper and lower compartments).
6. Design cubicle heaters to operate at half voltage (208V equipment energized at 120V).
7. Ground bus attachments shall be via A. B. Chance studs.
8. Provide bus to cable termination connections with removable boot insulating covers.
9. Main bussing shall run continuously through the lineup and shall include a full sized neutral bus, isolated and supported in the same manner as the phase busses.
10. Bus material shall be copper, silver plated at connection points.

Submittals

1. Furnish with each metal-enclosed switchgear assembly a set of drawings complete with a bill of material and showing the following: Typical front views and open side views for each bay as well as typical components, their positions, and available space for cable termination; an anchor bolt plan with dimensions; a one-line diagram; and appropriate wiring diagrams
2. Comprehensive instruction manual for installation and operation of each component
3. Certification of ratings of the basic switch and fuse components and the integrated metal-enclosed switchgear assembly consisting of the switch and fuse components in combination with the enclosure(s)
4. Certification of voltage, current, fault, and BIL ratings
5. Metering equipment and ratings
6. Protective equipment shop drawings
7. Manufacturer's technical bulletins for each protective relay or device
8. Component lists
9. Nameplate schedule
10. Factory and on-site testing procedures
11. Factory test records

12. Shipping split and bus connection procedures
13. Leveling requirements and tolerances

Products, Material and Equipment

1. Approved Switchgear manufacturers:
 - a. ASCO-Delta
 - b. Russelectric
 - c. Cutler Hammer
2. Power Circuit Breaker manufacturer:
 - a. Cutler Hammer Vacuum Breakers (VCP-W), no exceptions

Installation, Fabrication and Construction

1. Incoming line section shall consist of one or more air load interrupter switch(es), quick-make, quick-break, three-pole, gang operated.
2. The switchgear assembly shall consist of individual vertical sections housing combinations of circuit breakers and auxiliary equipment, bolted together to form a rigid metal-clad assembly with grounded steel barriers between compartments.

Enclosure Construction

1. Construct metal-enclosed switchgear in accordance with the minimum construction specifications of the fuse and switch manufacturer to provide adequate electrical clearances and space for fuse handling.
2. Give consideration to all relevant factors such as controlled access; tamper resistance; corrosion resistance; protection from ingress of rodents, insects, and weeds; arcing faults within the enclosure.
3. Each bay shall be unitized monocoque construction to maximize strength, minimize weight, and inhibit corrosion.
4. Each bay containing high-voltage components shall be a complete unit in itself, with full side sheets resulting in double-wall construction between bays. Side and rear sheets shall not be externally bolted to guard against unauthorized or inadvertent entry.
5. To guard against corrosion, all hardware, all operating-mechanism parts, and other parts subject to abrasive action from mechanical motion shall be nonferrous materials, galvanized, or zinc-nickel-plated ferrous materials. Cadmium-plated ferrous parts shall not be used.
6. Do not use externally accessible hardware for support of high-voltage components or switch-operating mechanisms within the switchgear.
7. The integrated switchgear assembly shall have a BIL rating established by test.

Door Construction

1. Doors shall have 90-degree flanges and shall overlap with the door openings. Weld door flanges at the corners and form with a double bend so that the sheared-edge flanges at the top and both sides fold back parallel to the inside of the door.
2. Door handles shall be padlockable and, on outdoor gear, shall incorporate a hood to protect the padlock shackle from tampering.
3. Provide at least three concealed, interlocking, high-strength latches for doors over 40 inches in height. Provide doors that are less than 40 inches in height with 2 latches.
4. Doors giving access to interrupter switches or interrupter switches with power fuses shall be provided with a wide-view window and constructed of an impact-resistant material to facilitate checking of switch position without opening the door.
5. Provide doors giving access to high-voltage components with a sturdy, self-latching door holder which shall be zinc-nickel plated and chromate dipped. Provide full-height hinged covers over low-voltage compartments with a galvanized rod-type door holder. In addition provide an internal protective screen, bolted closed, to guard against inadvertent entry when the enclosure door is open.
6. Doors giving access to fuses or fused voltage transformers shall have provisions to store spare fuse units, refill units, or interrupting modules.

Insulators and Bushings

1. The interrupter switch and fuse-mounting insulators, main-bus support insulators, insulated operating shafts, and push rods shall be of a cycloaliphatic epoxy resin system, with homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs.
2. Provide isolating through-bushings for the switchgear assembly between all bays to guard against the propagation of a fault from one bay into the adjacent bay.
3. For outdoor or drip-proof applications, install a drain channel above the isolating through-bushings as a backup for the bay-to-bay gasketing to prevent moisture from the bushing or the bus.
4. The bushings shall be of a nontracking, self-scouring, nonweathering cycloaliphatic epoxy resin. Such bushings shall be the only dielectric insulating material between the energized bus conductor and the ground plane. Isolating systems that incorporate multiple insulating materials in series shall not be acceptable.
5. The overall length of the bushing shall be a maximum of 9½ inches from end to end. The bushings shall provide a minimum of 12½ inches of leakage distance between the energized bus conductor and the ground plane.
6. The bus conductor shall not be molded or cemented into the bushing.
7. Do not cover the bus conductors with any insulating material in an effort to achieve BIL or increased leakage distance at locations where the bus passes through the bays.
8. Close openings between the bushings and bus conductors with a semiconducting grommet. Fiberglass or porcelain shall not be used for such purpose.
9. Bushing bus conductors and main bus conductors shall be designed for direct connection and shall not require laminated or flexible bus connections.

High-Voltage and Ground Bus

1. Bus supports, bus, and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switchgear.
2. Equip bus to where cable will be terminated with grounding provisions. Provide grounding provisions on the ground bus in such bays as well. Shop grounding pigtailed use Salisbury ground ball studs.
3. Bus and interconnections shall consist of copper bar CA110, square edge, hard temper per ASTM B187. Bolted copper-to-copper connections shall have silvered interfaces and shall be made with ½"—13 stainless-steel bolts with two brass flat washers per bolt, one under the bolt head and one under the nut, and with a stainless-steel split lockwasher between the flat washer and the nut. Tighten these bolts to 35 foot-pounds torque.
4. Provide a ground bus of short-circuit rating equal to that of the integrated assembly (or ground connection, in single-bay switchgears), maintaining electrical continuity throughout the switchgear.
5. In each bay, bolt the ground bus (or connector) to a nickel-plated steel bracket which shall be welded in place.
6. For multi-bay metal-enclosed switchgear assemblies, provide two ground cable connectors accommodating No.2 through 500 Kcmil conductors for connection of ground bus to station ground.

Power Circuit Breakers

1. Provide Eaton vacuum breakers (VCP-W), metal enclosed, drawout, motor operated, with auxiliary contacts for remote monitoring of open, closed, and alarm conditions.

Protective Bus Relays

1. Provide Schweitzer relays.

Finish and Features

1. Achieve full coverage at joints and blind areas by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.
2. All surfaces shall undergo a thorough pre-treatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied.
3. For outdoor switchgear, after pretreatment, apply protective coatings to resist corrosion and protect the steel enclosure. Representative test specimens coated by the enclosure manufacturer's finishing system shall satisfactorily pass the following tests:
 - a. 4000 hours of exposure to salt-spray testing per ASTM B 117 with Underfilm corrosion not to extend more than 1/32 inch from the scribe as evaluated per ASTM D 1654, Procedure A, Method 2 (scraping). Loss of adhesion from bare metal not to extend more than 1/8 inch from the scribe.
 - b. 1000 hours of humidity testing per ASTM D 4585 with no blistering as evaluated per ASTM D 714

- c. 500 hours of ultraviolet accelerated weathering testing per ASTM G 53 using lamp UVB-313 with no chalking as evaluated per ASTM D 659, and no more than a 10% reduction of gloss as evaluated per ASTM D 523
 - d. Crosshatch adhesion testing per ASTM D 3359 Method B with no loss of finish
 - e. 160-inch-pound impact followed by adhesion testing per ASTM D 2794 with no paint chipping or cracking
 - f. Oil resistance testing consisting of a 72-hour immersion bath in mineral oil with no shift in color, no streaking, no blistering, and no loss of hardness
 - g. 3000 cycles of abrasion testing per ASTM 4060 with no penetration to the substrate
- 4. For outdoor enclosures, apply a heavy coat of insulating "no-drip" compound to the inside surface of the roof to prevent condensation.
 - 5. The finish shall be light gray, satisfying the requirements of ANSI Standard Z55.1 for No. 61 or No. 70. - or shall be olive green, Munsell 7GY3.29/1.5 for outdoor switchgear. Include an inside baffle with louvered openings. Vents for outdoor switchgear shall be rain-resistant, corrosion-resistant, and shall have an inside screen.
 - 6. Lifting eyes shall be removable. Sockets for lifting eyes shall be blind-tapped.
 - 7. For outdoor switchgear, door openings shall have resilient compression gasketing to prevent water from entering the enclosure. Gasket seals shall be provided at the top and side edges of adjoining bays to prevent water entry between the double walls.
 - 8. For outdoor switchgear, cover the top and both sides of bus openings between bays with channel gasketing as an additional protection against entrance of water.
 - 9. Outdoor switchgear roofs shall be weather-sealed in place with a suitable sealant.
 - 10. For outdoor switchgear, provide space heaters with sheaths of high-temperature chrome steel to maintain air circulation inside the enclosure. There shall be a space heater in each bay. Heater circuits shall have low-voltage breakers and thermostats.
 - 11. Provide safety grounding cables per switch.

Delivery, Storage and Handling

- 1. Package and ship breakers and accessories separately from the switchgear structures.
- 2. Equip switchgear to be handled by crane. Where installation by crane is not possible, switchgear shall be capable of being moved on rollers or skids. Jacking into place shall not damage the equipment.

H. Medium Voltage Wire, Cables and Terminations

Basis of Design

This section applies to the design and installation relating to wire and cable systems and terminations.

For the MV Wire, Cable and Terminations [Standard Specifications click here](#).

Design Criteria

[See SD drawings](#)

Submittals

For medium voltage systems, refer to MV Wire, Cable and Terminations standard specifications.

Products, Material and Equipment

See [Preferred Vendors & Products table](#)

Installation, Fabrication and Construction

1. See [Preferred Vendors & Products table](#)
2. Medium voltage cable splices and connections are often placed in tunnels and manholes open to non-electrical workers; thus splices shall be provided with protective covers and junction boxes with protective cages. The Consultant shall investigate and work with Engineering Services in designing appropriate worker protection barriers.
3. Conduits for medium voltage installations are rigid steel in buildings and street crossings; schedule 40 PVC in direct buried or concrete encased applications; and cable tray in tunnels. Medium voltage cable shall not be direct buried.
4. Size cable junction boxes to allow future expansion of the cable system.

I. MV WIRE, CABLE AND TERMINATIONS – STANDARD SPECS

STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. 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 need 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 01 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
 - 2. National Fire Protection Association – NFPA
 - 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 one (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](#).

J. MV Load Interrupter Switches

Basis of Design

This section applies to the design and installation relating to load interrupters (switches).

Design Criteria

1. 13.8kV equipment shall be 15kV class; 2.4kV and 4.16kV equipment shall be 5kV class.
2. Space for metering CT's and PT's may be required in the switch enclosures.
3. Provide barriers to meet Washington State rules. Air break switches require an insulated barrier between line and load contacts when the switch is open to comply with State Code requirements.
4. Equipment switches shall be fused for coordination with the rest of the University's power distribution system. Refer to the University's short circuit studies for design fault duties.
5. Switches shall be able to be configured and operated according to UW High Voltage Shop operation procedures for closed transition switching. In a primary-select configuration, allow switching operations between two feeders so that one feeder can be isolated, de-energized, and "cleared" for shutdown while the other feeder continuously serves building loads without interruption. Note that in this configuration the load side of both incoming feeder switches is always energized when either switch is "opened".
6. Switch line-ups with the "primary select" configuration shall be bus type construction that can accommodate addition of future switches by extension of existing busses. Switch enclosures shall be equipped with removable plates to allow extension of the busses on both sides ends of the lineup. New switches shall match the manufacturer and type of existing switch line-ups they are being added to. Additional spaces and enclosures may be required to accommodate bending radius requirements of feeder cables.
7. When sizing vaults or rooms for primary switch line-ups always design space for the addition of future switches. In addition to future building switches, also allow space for the installation of a switch for construction power. Space for future switches shall be designed and noted in the design documents.
8. Where expansion space is available, design switches for future extensions to additional equipment bays on both ends of the lineup.
9. Do not use oil and gas insulated switches. (Exception: Pad-mount transformers with integrally equipped switches may be oil filled.)

Submittals

1. Equipment catalog cuts
2. Dimensioned installation drawings
3. Certified test reports of full load, load interrupt and fault current and close and latch ratings

Products, Materials and Equipment

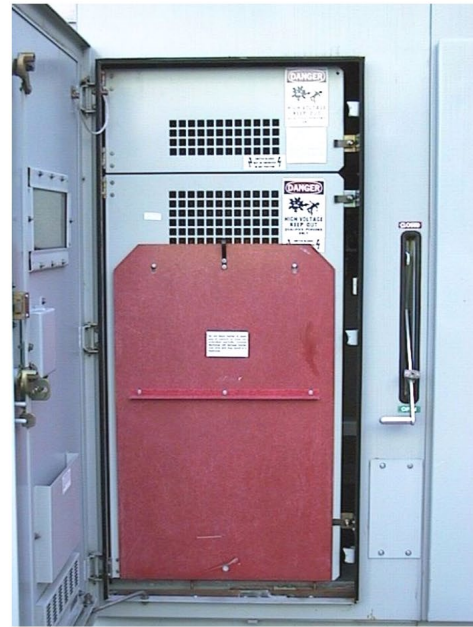
1. Approved manufacturers: S&C Electric, no exceptions.
2. Interrupter switches shall have a one-time or two-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the switchgear. These ratings define the ability to close the interrupter switch either alone (unfused) or in combination with the appropriate fuse, once or twice (as applicable), against a three-phase fault with asymmetrical current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at maximum voltage. Certified test abstracts establishing such ratings shall be furnished upon request.
3. Interrupter switches intended for manual operation shall be operated by means of an externally operable, non-removable handle. The handle shall have provisions for padlocking in both the open and closed positions. Interrupter switches intended for power operation shall be operated by means of a switch operator expressly designed to be compatible with the interrupter switch.
4. Interrupter switches shall utilize a quick-make quick-break mechanism installed by the switch manufacturer, which shall swiftly and positively open and close the interrupter switch independent of the switch-handle or switch operator operating speed.
5. For manually operated interrupter switches, and for interrupter switches operated by direct motor drive switch operators, the quick-make quick-break mechanism shall be integrally mounted to the switch frame.
6. Interrupter switches shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction such that the frame intercepts the leakage path which parallels the open gap of the interrupter switch, to positively isolate the load circuit when the interrupter switch is in the open position.
7. Provide interrupter switches with a single blade per phase for circuit closing including fault closing, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted.
8. Interrupter switches shall have a readily visible open gap when in the open position to allow positive verification of switch position.
9. Interrupter switches shall be hinged at the bottom of the switch blade to allow insertion and removal of a full isolating barrier in the open gap when the switch is opened with a hotstick.
10. Provide reverse cable entrance/exit on all bays.
11. Provide copper main and ground bus as well as copper terminals on switches and fuses.
12. Provide isolating barrier per switch compartment. The interrupter switch housing shall have provisions guides/tracks/brackets to facilitate installation and hold the barrier in place (when installed). Barrier shall be of NEMA GPO3-grade fiberglass reinforced polyester. **WARNING: REQUIREMENT FOR BARRIER IS A NON-STANDARD COMPONENT.**
13. Provide grounding stirrups in the line and load compartments such that, with the barrier installed, grounding can be achieved without entering an energized compartment.
14. Grounding jumpers are to be provided with clear insulation; Part No. 3611-215 for Salisbury "ball-type" studs and Part No. 3611-479 for S&C standard studs.
15. Salisbury "ball-type" ground studs are required on switch terminals of "switch-only" entrance bays. Standard S&C ground studs are required on terminals of "fused-switch" feeder bays.
16. All grounding landing pads shall have a "Chance" stud ball.

17. Pads for switch line-ups with the “primary select” configuration shall have space for additional switches to be added in the future. Where space is limited and allowing space for future switches is difficult, contact Engineering Services for resolution.
18. “Kirk-Key” system is not allowed unless specifically requested by the Engineering Services and Campus Utilities and Operations.
19. All switches installed in exterior areas, utility tunnels, vaults, and other areas exposed to steam condensation, corrosion, and moisture, shall be NEMA 3R exterior type construction. NEMA 3R switches have larger space requirements and may be mounted on a stand-off frame.
20. Approved manufacturer: S&C.
21. Load side of switch shall be on the bottom.
22. If equipped with lightning arresters, they shall be located on the load side of the switch.
23. Pad Mount – Manually operated, elbow connected, compartmentalized & fused. May be integral with a transformer.
24. Provide two sets of NO and NC contacts for remote monitoring the switch position. Wire the switches out to a terminal strip (typically located near the top of the bay) that is accessible for safe access when the switch is energized.

Typical primary select interrupter switch and isolation barrier configurations:



16K – Figure 1
Primary Select 3-Bay Switching



16K – Figure 2
Isolation Barrier in Storage Position



16K – Figure 3
Isolation Barrier Being Inserted



16K – Figure 4
Barrier Isolating Switch

Fuses

1. Solid-material power fuses shall be of the solid-material type and shall utilize refill-unit-and-holder or fuse-unit-and-end-fitting construction. The refill unit or fuse unit shall be readily replaceable.
2. For switchgear rated up through 270 MVA at 4.16 kV and 600 MVA at 13.8 kV, mountings for solid-material power fuses shall be disconnect style. Non-disconnect style mountings for power fuses shall be used only where higher ratings are required.
3. Solid-material power fuses shall be equipped with a blown-fuse indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting.
4. Solid-material power fuses in feeder bays shall be equipped with grounding provisions on the load side of each fuse and on the enclosure ground bus.
5. SM-5S fuses are required for 13.8kV equipment. SM-5S fuses are required for 2.4kV and 4.16kV equipment.
6. Fuse ratings for 13.8kV equipment is to be provided per the table below.

OVERCURRENT DEVICE RATINGS		
Transformer size (KVA)	Fuse Rating (A)	Main Breaker Pick up (A)
300	25	-
500	40	800
750	65	1200
1000	80	1800
1500	125	2400
2000	150	3200
2500	200	4400

Installation, Fabrication and Construction

1. Switches may be installed indoors or outdoors in non-secure areas.
2. A category "A" enclosure is to be provided for equipment installed on non-secured locations.
3. Provide features and requirements for enclosures similar to medium voltage switchgear requirements.
4. Each bay is to be furnished with laminated plastic nameplates.
5. Indoor enclosures shall be drip-proof. All enclosures shall be of compact height: 90" for indoor installations and 93" for outdoor installations.
6. For outdoor installations, provide features and requirements for enclosure ventilation, lifting eyes, gasketing and sealing, and space heaters similar to medium voltage switchgear requirements. A thermostat and low-voltage circuit breaker is to be provided in the heater circuit on outdoor equipment.

7. Load connections may be direct (transformer throat) or via cable. Note: Phase rotation is a concern at transformer terminals and may require transition space.
8. Campus phase sequence is C-B-A. Cable termination positions in switches shall be A-B-C left to right, top to bottom, or front to back when viewed from the front of the switch.

K. DRY-TYPE, MEDIUM-VOLTAGE TRANSFORMERS – STANDARD SPECS

STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. 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 - Requirements for Ventilated Dry-Type Power Transformers 501 kVA and Larger, 3-Phase with High- Voltage 601 - 34,500 V, Low-Voltage 208Y/120 to 4160 V
- 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 5T20 - 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 on manufactured unit.
 - 1. 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. 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 22 degrees C.
2. Temperature rise based on a 3 degrees C ambient with a maximum 4 degrees 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. Ventilation openings shall be constructed to prevent any foreign object intrusion. 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 shall have adequately sized stress cone terminations 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.

L. Power System Studies

Basis of Design

This section applies to the requirements for the performance of power system studies by both the Design Engineer and the Contractor.

For this section's [Standard Specifications click here](#).

Background Information

1. Engineering Services Facilities Information Library (FIL) contains historical Short Circuit and Coordination Studies for reference. Fault calculations within FIL are finite and are not calculated to all extremes of the primary distribution system.
2. For other campus sites, contact the local utility to establish the initial available fault current.

Design Criteria

1. The Consultant is responsible for providing design level short circuit calculations to ensure that the design and estimates are based on the correct sized equipment. For the Seattle campus where the studies are not available in FIL, the Engineer of Record is to use an infinite bus calculation used on primary winding of the utility service transformer.
2. The Contractor required to perform a Short Circuit and Coordination Study once the actual equipment being provided has been determined. The Contractor shall utilize the study results as follows:
 - a. Verify that all equipment being provided is correctly rated.
 - b. Calibrate and test the equipment per the settings provided by the Coordination Study.
 - c. For substations with spot or distributed network protection, provide calculations and settings to configure the network protection relays.
 - d. For equipment that has a maintenance feature, include that calculation.

Submittals

Refer to the [Short Circuit & Coordination Studies standard specifications](#).

Products, Materials and Equipment

Refer to the [Short Circuit & Coordination Studies standard specifications](#).

Installation, Fabrication and Construction

Refer to the [Short Circuit & Coordination Studies standard specifications](#).

M. SHORT CIRCUIT AND COORDINATION STUDIES – STANDARD SPECS

STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. 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 01 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. Arch Flash hazard/risk categories.

3.03 SHORT CIRCUIT STUDY

- A. Assumptions for Short Circuit Study calculations:

At the West Receiving Station (Fault Current @ 13,800V)		
Fault Description	Amperes	X/R
3-phase fault*	32.4kA	11
L-G fault	2kA (resistance limited)	

* 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 Electrical Identification, for a sample “Arc Flash Warning Label”.

- D. In addition to the O&M requirements, provide one (1) hardcopy and two (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.

N. Vaults

Basis of Design

This section covers manufactured structures for electric facilities located outside of buildings, including vaults, handholes and pads.

Design Criteria

1. Comply with requirements specified in Seattle Amendment 450-19(a)(1) and WAC 296-46-370 (Boxes and Fittings).
2. Refer to section 16B for additional criteria when designing vaults and raceways for the primary distribution system.
3. Water infiltration is not acceptable. Determine surrounding hydraulic conditions that may cause this to happen (includes entry via existing raceways). Review options.
4. Generally, installations need to be H-20 rated.

Submittals

1. Manufacturer's catalog data

Products, Material and Equipment

Manufacturers

1. Utility Vault Co.
2. Renton Concrete Products
3. Fog-Tite
4. Quazite

Installation, Fabrication and Construction

1. Size vault tops to match their vaults.
2. Handhole and vault covers shall be factory-marked "ELECTRIC", "LIGHTING", "FIRE ALARM" as needed.
3. Excavation, bedding material, installation and backfill shall be according to manufacturer's recommendations. Structures equipped with floors or solid bottoms shall be water tight throughout.
4. Equip conduit entering through vault walls with end bells installed flush with the wall and made watertight. Conduits entering through the bottom of handholes & vaults shall comply with WAC 296-46-370.
5. Conduit entry into the vaults shall be located as close as possible to end walls to facilitate cable routing along the walls and optimize interior vault space. Do not locate entry through the center line causing cables to occupy the central space of the vault blocking out space for future connections.

6. Coordinate the vault identifier with Engineering Services. Label the vault in a permanent manner in a visible location, typically on the top of the vault. The Consultant shall specify the method by which the permanent identifier will be added to the vault. This is dependent upon the vault composition (cement, plastic composite, metal, etc.).
7. Access hatches and doors for vaults shall be lockable. When equipped with ladders, locks and doors shall be operable from the ladder.
8. Ladders for vaults shall be equipped with a full double rung extension to allow safe access/egress. Single pole type extensions are unstable and are not acceptable.

O. Emergency Power Systems

Basis of Design

This section applies to the design and installation relating to emergency power systems.

Background Information – UW Seattle Campus

1. The University owns and operates central plants known as the Emergency and Standby Power System (ESPS). The system consists of 4.16kV and 2.4kV emergency distribution systems. The generator plants are located in the central Power Plant and the West Campus Utility Plant. Both are operated and maintained by the Power Plant staff. The distribution systems are operated and maintained by Campus Operations High Voltage Shop. Most new facilities shall be served from the campus ESPS system.
2. The 2.4kV, 3 phase, 3 wire ungrounded delta emergency distribution system is being phased-out and buildings served from this system are in the process of being converted to 4.16kV. In the future the 2.4kV system will only serve Power Plant loads.
3. The 4.16kV, 3 phase, 3 wire, low resistance grounded-wye emergency distribution system is supplied power from a 4.16kV Diesel Generating Plant that is classified as a code compliant emergency generating source. The Medical Center and most University facilities built since 1992 are served from this system. Expansion of the 4.16kV distribution system throughout the campus is in progress. In the future all campus buildings except the Power Plant will be served exclusively by the 4.16kV ESPS systems.
4. The ESPS is configured into three major Plants:
 - a. UW Medical Center
 - b. Central Power Plant
 - c. West Campus Utility Plant
5. During the initial phases of design, consultants shall confer with Engineering Services to determine the source of emergency power. Designs shall take into account this future service connection so that the facility can be re-fed at minimum future cost and rework to the electrical distribution system. Reserve space to accommodate the future equipment.
6. The 4.16kV campus ESPS shall serve most NEC Article 517, 700, 701, and 702 emergency loads. The 4.16kV campus emergency system has been approved by Seattle's DCI to serve these loads with the following clarifications:
 - a. Future high-rise buildings (SBC Section 1807) will also require redundant feeders, or on-site emergency generation equipment.
 - b. NEC classified "emergency," "legally required standby," and "optional standby" loads may be powered from the campus ESPS provided the capacity, load pickup, and load shedding requirements of NEC 700-5 are met.
 - c. Oil switches and other significant sources of fuel shall not be used in the tunnels or electrical rooms that contain portions of the ESPS.

7. NEC Article 702 Optional Standby loads will be permitted on the campus emergency power system only on a selective basis, and Engineering Services must approve each connection of this category. The system is not intended to provide firm or uninterruptible power for computers, lab equipment, etc. It can be used to provide power for life sustaining requirements such as pumped water to fish tanks, protection of facilities and personnel from environmental hazards, and to protect the facilities and equipment from damage, e.g. sanitary lift stations and sump pumps. These loads will be subject to load shed if the generation plant develops problems.
8. During the initial phases of design, consultants shall confer with Engineering Services to determine the source of emergency power. The primary purpose of the campus ESPS is to supply power centrally and thus economically to as many facilities as possible. New connections to the ESPS are limited to loads 200kVA/facility or less. The 200 KVA will be the combined total for "legally required" emergency loads (i.e. egress lighting, fire alarm, etc.) and some optional standby loads. Facilities with large emergency power requirements shall require a dedicated on-site generator to prevent overloading of the campus ESPS. Consult with Engineering Services for requirements and location of on-site generators.
9. The 4.16 kV Emergency Power System for the UW Medical Center supplies power for emergency, legally required standby, and optional standby system loads. This system has sufficient capacity to provide power for all the loads currently connected to the system. An Allen Bradley PLC-based Central Monitoring and Control System (CMCS) monitors and controls the system and meets NEC 700-5(b) load management priority requirements. In the event a generator goes off-line or some other critical component fails, the CMCS protects the system by shedding load on a prioritized basis. A hardware and software addition to the existing CMCS system is required when new and existing facilities are added to this system. Typically, the UW Project Manager will issue a purchase order to Allen Bradley IAS for hardware and software procurement and integration. The design engineer is responsible for providing detailed-engineered installation drawings as a part of the overall public works bid documents. These should include detailed terminal strip interconnection diagrams. Sample documents are available from previous projects. Contact Engineering Services for more information.

Design Criteria

1. Most new facilities shall be served from the campus ESPS system or provided with on-site generators for large block load applications.
2. Some existing facilities and systems have battery operated fixtures and UPS systems for emergency power. These systems are costly to operate and maintain, therefore they shall be phased out and replaced in major renovation projects. They shall not be installed in new facilities.
3. Emergency services for many existing facilities are nothing more than a connection ahead of the main breaker. While these systems are no longer allowed by code, they remain grandfathered by the codes they were installed under and only to the extent allowed by Authority Having Jurisdiction (AHJ). When feasible, renovation and remodel projects for

these facilities shall include an upgrade to or addition of a code-compliant emergency power service.

4. Many older facilities have no emergency power service. When feasible, renovation and remodel projects for these facilities shall include the addition of an emergency power service.
5. Contact Engineering Services for questions concerning which buildings are on the campus ESPS, new connections to the campus Emergency and Standby Power System (ESPS), and integration into the associated Central Monitoring and Control System (CMCS).
6. At a minimum, provide a dedicated emergency panel and associated distribution system. In older University buildings, these panels have been designated as the building's "X-Panel". For facilities where battery backup lighting fixtures are the obvious choice, the emergency distribution system (X-Panel concept) shall still be required such that the panel and therefore its distribution can be re-fed from the central ESPS in the future.

Submittals

1. Provide standard industry submittal requirements.
2. For generator and other equipment, provide shop drawings including the following:
 - a. Catalog information,
 - b. Equipment layout and elevations,
 - c. Equipment wiring diagrams and connection drawings,
 - d. Operation and maintenance manuals,
 - e. Shop drawings.

Products, Material and Equipment

1. Generators 250kW and larger shall be Caterpillar.
2. Generators smaller than 250kW shall be Caterpillar, Onan or Kohler.
3. Transformers for the 2.4kV emergency system shall be dual rated 2.4/4.16kV. Transformers shall have delta (primary) to wye (secondary) configuration. The primary side shall have the delta configuration whether it is connected 2.4kV or 4.16kV.
4. Refer to requirements under related sections.

Installation, Fabrication and Construction

1. Coordinate generator location with landscape aesthetics, fuel storage and noise mitigation.

Building Secondary Distribution

P. Service Types

Basis of Design

This section applies to the design and installation relating to building services.

UW Service Classifications

For design purposes, the University has designated several building power service classifications to accommodate different facility uses and differences in available power service.

1. **CLASS N1** - Spot Network - to be used in the University of Washington Medical Center, Health Sciences, and major research and laboratory facilities.
2. **CLASS N2** - Primary Radial - to be used in most major education, administration, office and support facilities. This class has two subclasses:
 - a. **CLASS N2S** - Includes a secondary tie to a second service bus in the same building (double ended substation) or to a separate building.
 - b. **CLASS N2P** - Includes a primary selective switching concept. Only to be used if Class N2S is not possible.
3. **CLASS N3** - Secondary Radial - to be used only for small annexes, selected branch campus facilities or other outlying facilities.
4. **CLASS E1** - Hospitals and health care facilities, i.e. University of Washington Medical Center. Designed to meet the requirements of NEC, Article 517. Requires bypass/isolation switches.
5. **CLASS E2** - Health Sciences, and major science research and laboratory facilities. Designed to meet the requirements of NEC, Article 700, 701, 702. Requires bypass/isolation transfer switches.
6. **CLASS E3** - Academic, administration and support facilities. Designed to meet NEC, Article 700, 701, 702. Does not require bypass/isolation transfer switches.
7. **CLASS E4** - Small annex, addition or similar structure. Designed to meet NEC, Article 700, 701, 702. For facilities not connected to the campus ESPS. Does not require bypass/isolation transfer switches.

Design Criteria

1. All services shall have a space at the main electrical service to allow temporary generator hookup to the facility. The space shall be marked as such. Facilities housing critical operations (i.e. Medical, Research, Laboratories, Data Centers) shall have spare breakers in these spaces.
2. All services shall be fully rated. Series rating is not acceptable.

Service Transformer Sizing

1. **CLASS N1**: Size the transformers serving as one of three transformers in a spot network to carry 50 percent of the "Code" building demand load. Note that the network has to be able

to operate in the “n-1” transformer mode. The increased load capacity from internal fan cooling is to be used only for building spare capacity.

2. CLASS N2P, N2R, E1, E2, E3 and E4: Size the transformer to carry their respective calculated "Code" demand load. The increased load capacity from internal fan cooling is to be used only for building spare capacity. Non-fan cooled transformers shall be size to carry building calculated demand load plus 20% spare transformer capacity.
3. CLASS N2S: Size the transformers serving as one of the two transformers in a distribution system to carry the entire building calculated "Code" demand load. Note that the system has to be able to operate in the “n-1” transformer mode. The increased load capacity from internal fan cooling is to be used for building spare capacity.

Submittals

Provide standard industry submittal requirements.

Products, Materials and Equipment

Refer to the requirements specified in individual Electrical sections.

Installation, Fabrication and Construction

1. UW Class N1 services (spot networks) shall be in vaults with concrete or solid masonry walls and ceilings per NEC 450-C.
2. Locate lock out relays for the spot networks protectors adjacent to each other.

Q. Power Layout and Provisions

Basis of Design

This section applies to the design and installation of building power distribution systems.

Design Criteria

1. This section contains the architectural, structural and mechanical provisions for the building electrical systems. The electrical designer shall coordinate these requirements with the other disciplines to insure these requirements are satisfied.
2. Use attached drawing, [Typical Building Power Distribution Riser](#), as a guide for building power systems.
3. Coordinate with Engineering Services the distribution concepts, including load calculations, calculated fault duties, protective device coordination methods and grounding practices being utilized on the design.

Architectural Provisions

1. Provide separate service entrance electrical rooms for each of the normal and emergency systems in the basement, preferably adjacent to the utility tunnel and on an exterior wall. Equipment access shafts to the outside and walk-in access from the tunnel system shall be provided wherever possible. The design shall take into consideration the possibility of flooding when below grade. Provide emergency power lights with battery back-up to illuminate main service equipment area. Provide at least one phone outlet in main electrical room.
2. Distribution within the building shall be via readily accessible electrical rooms and/or closets. These must be independent from all other types of rooms or closets, i.e., communications, telephone, custodial, audiovisual, etc.
3. As a general guide, provide one floor electrical distribution room to serve each 15,000 to 20,000 square feet.
4. Equipment room and equipment space requirements should exceed minimum NEC requirements and shall be large enough to accommodate the equipment along with space provisions for future equipment. Eventually, panels will become full, requiring the addition of new panels. This is true even for fairly new facilities and is especially prevalent in laboratory and science buildings. These future wall and floor space provisions shall be shown on the design drawings so that space is reserved. Typically, 6-foot hot sticks are used to work on high voltage equipment. Provide adequate working space per NEC, WAC 296-44 and the National Electrical Safety Code.
5. Distribution switchboards, panelboards, and dry transformers over 30 kVA shall be in electrical rooms. Rooms shall be stacked for riser efficiency, and be centrally located to keep feeder lengths to a minimum. Several rooms may be necessary to accommodate the building configuration and system design. Refer to attached drawing, [Typical Floor Electrical Room](#).

6. Closets should be a minimum 2 feet deep by 6 feet wide and equipped with full-width double doors opening into a building corridor.
7. Branch panels shall be located in closets located throughout the floor or wing. In laboratories and similar areas, branch panels may be mounted on or in common corridor walls.
8. Transformer ambient noise and EMF emissions from electrical equipment and risers can negatively impact the equipment and function in neighboring spaces. This includes spaces immediately above and below these rooms, closets and risers. Therefore, the space plan shall be reviewed to determine if modifications are required. Use H1 core steel and Unit DNP (Double Neoprene Pad - Neoprene pad isolators formed by two layers of ¼-inch to 5/16-inch thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate, permanently adhered together, 40 to 50 durometer) for the MV transformers.
9. Provide adequately sized access pathways for the repair, maintenance and eventual replacement of the equipment. Equipment access pathways shall be large enough to allow for the removal of transformers, primary switches and other large pieces of equipment. These paths of egress shall be shown on the building drawings. Weights of transformers could exceed floor loading if other than slab-on-grade basement areas are necessary for egress. Make sure that lifting eyes and floor loading are accommodated for in the design.
10. Padmount transformers and switchgear must be accessible by vehicular crane and have sufficient working space per NEC, WAC 296-44 and the National Electrical Safety Code.

Mechanical Provisions

1. Coordinate ventilation requirements in electrical rooms and closets containing transformers or other heat generating sources with mechanical engineer. Convection-type ventilation of the electrical rooms via air/access shafts to the outside has been used in the past at the University. Unfortunately, this allows dirt and debris to get into rooms and equipment, resulting in increased maintenance costs. Therefore, the ventilation shall be supplied and filtered by a ventilation system.
2. Coordinate fire protection requirements in electrical rooms and vaults with the Architect and Mechanical Engineer. The system shall satisfy the code while minimizing the risk of electrocution. Sprinklers in high voltage electrical vaults create extremely hazardous conditions when they discharge, creating an electrocution hazard for workers.
3. Avoid installation of mechanical piping and ductwork in electrical vaults, rooms or closets except where required for operation of the electrical equipment. Piping and ductwork must never be installed directly over any transformer or switchgear. Sprinklers installed to protect the electrical equipment are the only exception. Drain lines from the floors above shall not be piped through the electrical rooms below. It is not allowed to use drip pans as a mitigating means that would allow for the piping to be installed in these areas.

Structural Provisions

1. Provide concrete bases and housekeeping pads for all transformers and equipment, seismically designed with structural connections to the floor slab, and channel or angle iron frames for welded equipment fastening.

2. Provide supports and restraints for Seismic Zone III requirements for all equipment and raceways.
3. Coordinate conduit penetrations in slabs, floors, shear walls, structural members, and other structural elements.

Laboratory Buildings

1. Since laboratory buildings will need constant renovation to keep up with changing technology, they are divided up into lab modules. Each lab (one of more modules) will periodically need to be isolated from the rest of the building to facilitate the renovation without impacting the remainder of the building. Provide circuiting isolation for each lab module. All electrical systems shall be down fed to minimize the number of floor penetrations.
2. If utility corridors can be provided to serve a variety of purposes through laboratory areas, then it would be highly desirable to provide local panelboards in these utility corridors, dedicated to individual or small groups of laboratories.
3. Lab areas will be designed with the capacity of at least 1 power outlet per 30 square feet. Dedicated circuits will be supplied for all refrigerators, centrifuge and specialty devices. Provide hospital grade receptacles in all research laboratories and procedure rooms in the Health Sciences and other physical sciences.
4. Refer to attached drawing, [Laboratory Demand Load](#), to approximate power required for laboratory areas. Laboratory power systems shall be flexible to allow the anticipated increase in laboratory loads. Local distribution shall be provided based on calculated load. However, more generous conduit sizing, sleeving, space allocated in principal electrical cabinets or closets shall be provided to make it convenient to bring in new feeders to supply additional power for load increases.
5. Dedicated receptacles and isolated ground receptacles are often required for special or sensitive equipment. Extensive use of dedicated receptacles in laboratories can quickly use up all the circuit breakers in the branch circuit panelboard. The Electrical Engineer shall insure that these needs are identified on the room datasheets and that adequate panel space is provided. Define this early in the design process.

Classroom Services See [Academic Technologies Audiovisual Systems Integration](#)

Submittals

Provide standard industry submittal requirements.

Refer to requirements specified in related sections.

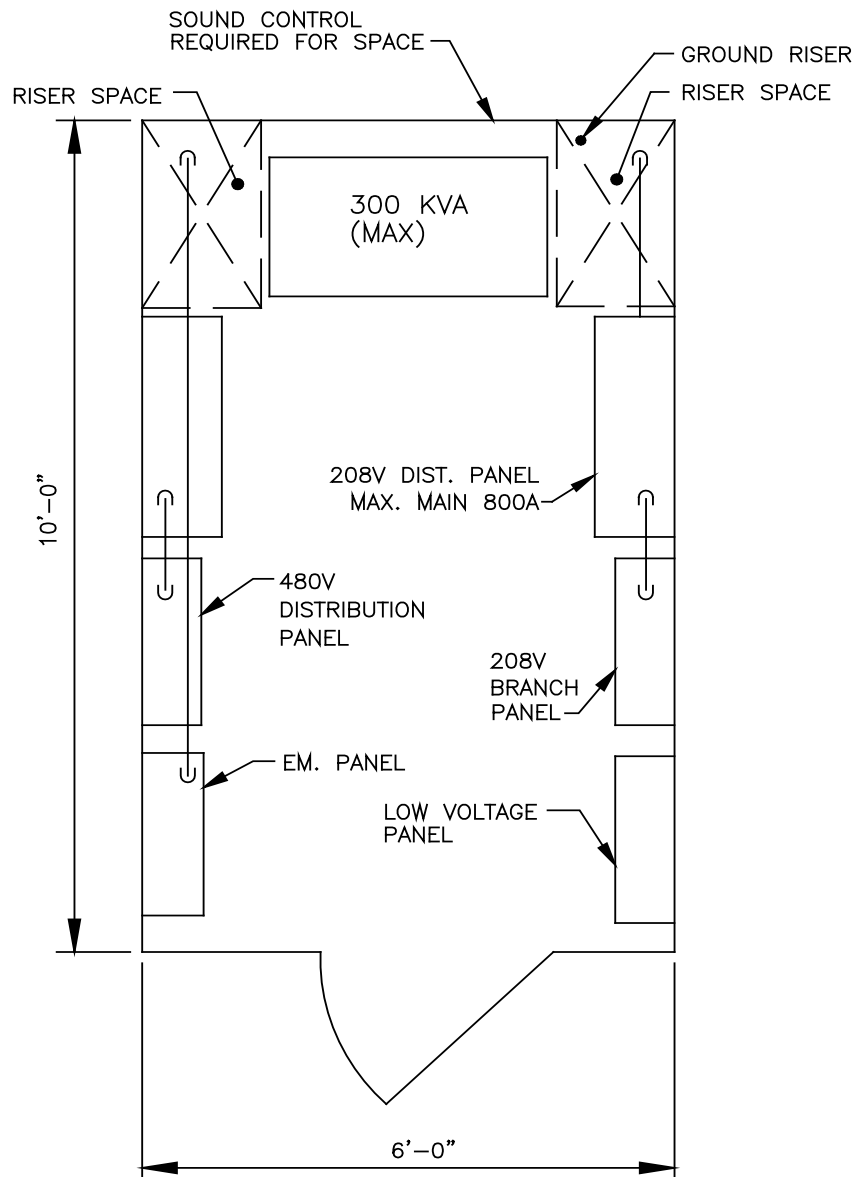
Products, Materials and Equipment

Refer to requirements specified in related sections.

Installation, Fabrication and Construction

Refer to requirements specified in related sections.

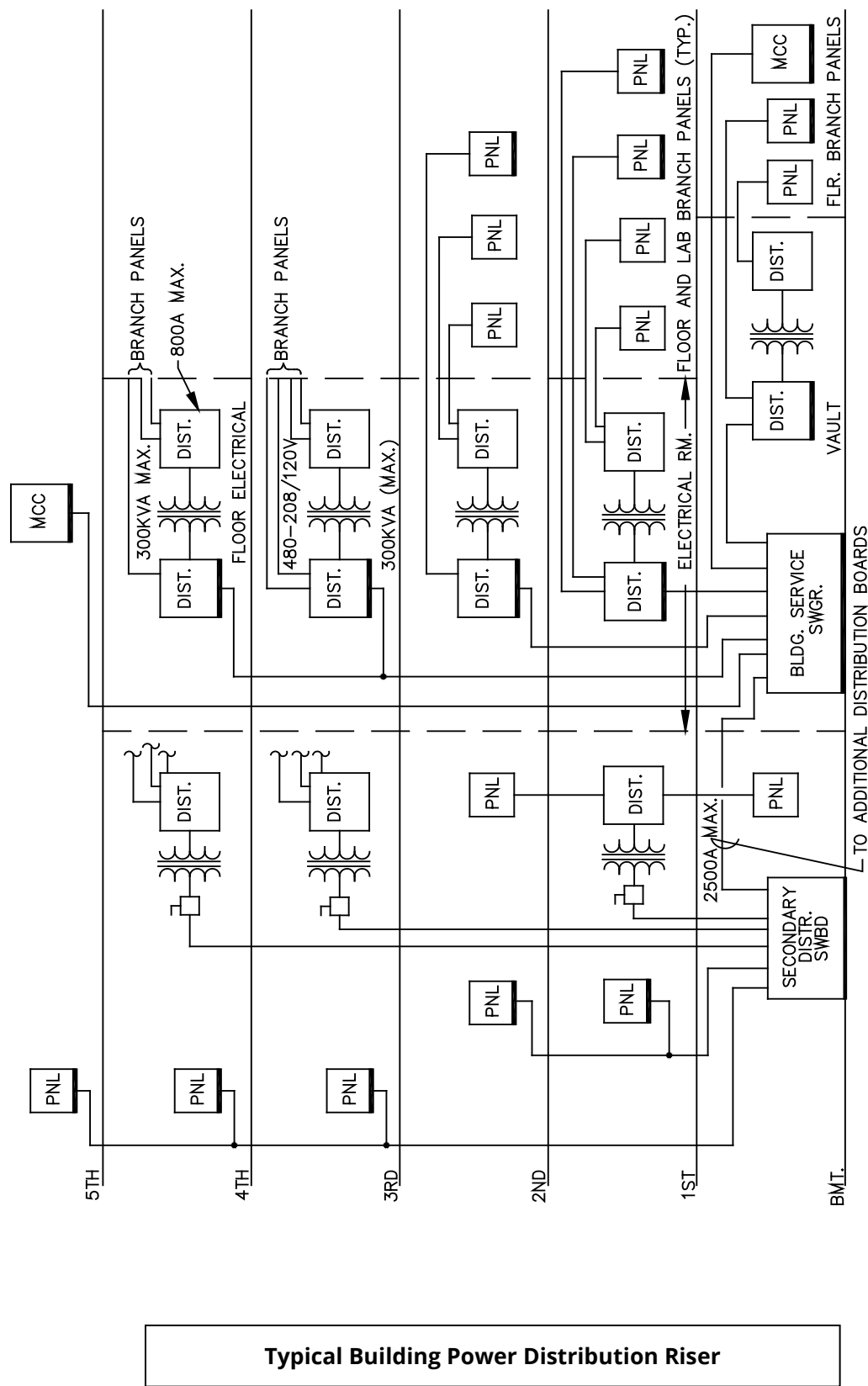
Typical Floor Electrical Room



NOTE:

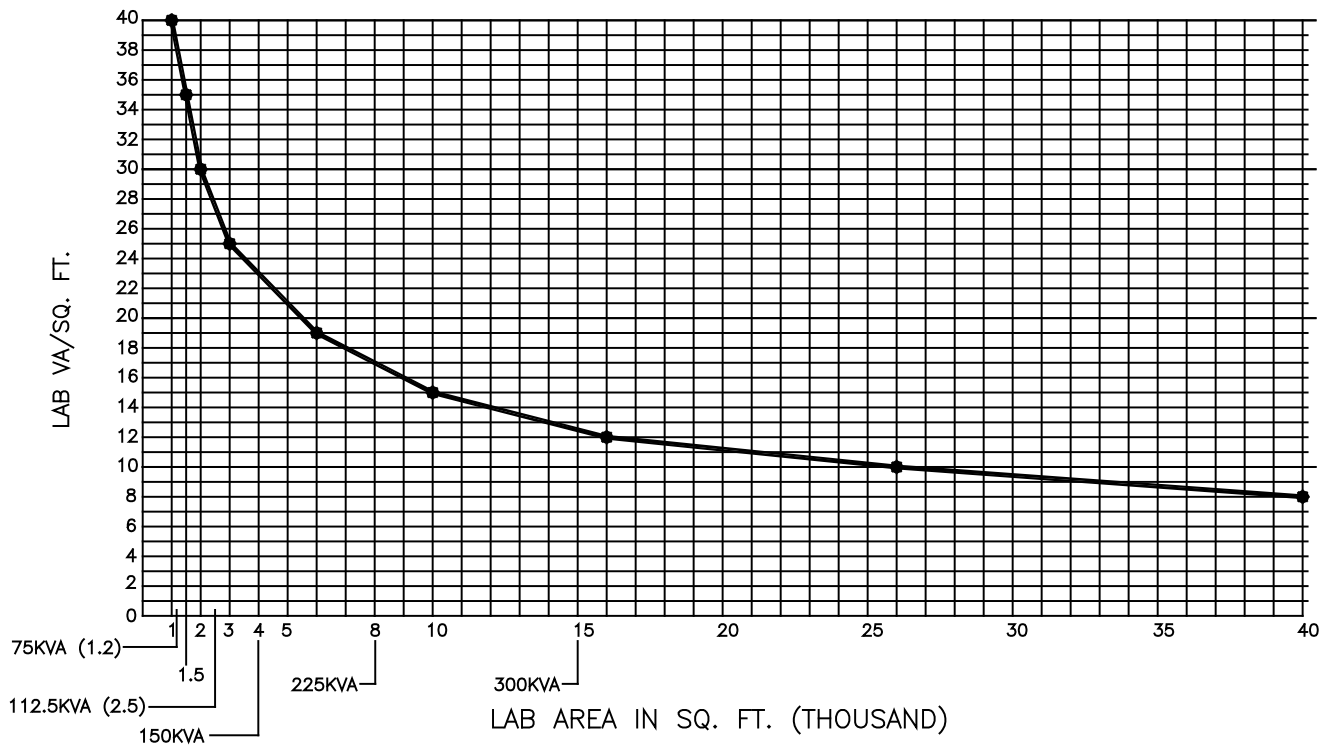
ADDITIONAL ROOMS OR CLOSETS MAY BE REQUIRED ON EACH FLOOR. ADDITIONAL SPACE MAY BE REQUIRED FOR LIGHTING CONTROL PANELS, CRITICAL OR EQUIPMENT BRANCH PANELS, FIRE ALARM PANELS, SUPERVISORY CONTROL PANELS, AND SPACE FOR FUTURE PANEL(S).

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- NOTES:
- 1.) USE CABLE & CONDUIT RISERS, AND FEEDERS NOT TO EXCEED 800A EACH.
 - 2.) A SINGLE RISER MAY FEED NO MORE THAN TWO DISTRIBUTION PANELS, OR THREE 480V BRANCH PANELS.
 - 3.) FOR SMALLER BUILDINGS OR LOADS, A SINGLE DISTRIBUTION BOARD MAY SERVICE UP TO 3 FLOORS WHEN LOCATED ON THE MIDDLE FLOOR.
 - 4.) 30% TO 40% SPARE SPACES AND AMPACITY SHALL BE PROVIDED.

Laboratory Demand Load



NOTES:

- EXCLUDING LIGHTING AND SPECIAL EQUIPMENT.
- EXCLUDING RELATED STORAGE, OFFICE, OR RECEPTION AREA.
- MINIMUM TRANSFORMER AND FEEDER SIZES NOTED.
(INCLUDES 40% SPARE CAPACITY)

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R. Low Voltage Wire and Terminations

Basis of Design

This section applies to the design and installation relating to wire and cable systems and terminations.

Design Criteria

All wiring shall be in raceway systems unless otherwise noted.

Products, Material and Equipment

1. Power conductors shall be stranded copper, 98% conductivity. Number 12 AWG is the minimum conductor size.
2. Insulation THWN or XHHW (Also THHN when 1/O or smaller)

Installation, Fabrication and Construction

1. Provide cable ties (limit torque on ties) in panelboards, cabinets, and other unconfined spaces. Group and lace wiring neatly, and do not tie to factory-installed wiring in equipment. Bundle and tag multi-pole circuits in laboratory surface metal raceway.
2. Branch circuits: Homeruns greater than 75 feet to first outlet shall be #10 minimum.
3. Crimp terminations larger than 8awg shall be of the hexacentric type.

S. Panelboards

Basis of Design

This section applies to the design and installation of panelboards.

Design Criteria

1. UW Class N3 services building panelboards shall be front accessible and utilize group mounted thermal-magnetic molded case circuit breakers. Load Centers are not acceptable.
2. For UW Class N1, N2S, and N2P services building panelboards, provide electronic trip units with long time, short time and ground fault (LSG) protection for molded case circuit breakers. Instantaneous protection shall not be provided since it limits coordination with downstream molded case circuit breakers. Two and preferably three levels of ground fault protection are desired. Selectivity is critical to the University in order to limit the extent of power outages.
3. Provide multiple lugs or feed-through type panels when required.
4. Laboratory panels shall have double lugs.
5. Provide all 208Y/120V panels with a dedicated, isolated, full size ground bus to serve future computer equipment, and separate equipment grounding conductor bus. Provide terminals for a minimum of 50% of panel circuits on each bus.
6. Provide isolation panels for Medical Center and other special applications when required.
7. Provide "service entrance" listed service entrance applications.
8. Series rated panelboards are not acceptable.
9. Panelboards shall be 200% neutral rated when serving high non-linear type loads.
10. Locate panels in electrical rooms, electrical closets, or utility hallways on each floor. Special rooms and laboratories with highly concentrated loads should have separate panels. Do not locate panels in janitor closets or toilet room entries. Locate panels near columns, on permanent corridor walls or other permanent features to prevent future relocations.
11. Surface mounted panels are preferred to flush panels. Surface mount panels in utility spaces. In finished areas provide flush mount with full height access to ceiling for future raceways. Provide a minimum of three ¾-inch spare conduits stubbed into ceiling space.
12. Consider service rated main breaker if adding a breaker causes operational difficulty.

Submittals

1. Shop drawings for review prior to manufacture
2. Panel schedules

Products, Materials and Equipment

1. Approved Manufacturers
 - a. Eaton/Cutler Hammer
 - b. ABB/GE

- c. Siemens
- 2. Cabinets and Fronts
 - a. Dead front type
 - b. Tight closing doors without play, when latched. Where remote controlled switch or contactor is mounted in panelboard, mount on same frame as panelboard interior with dedicated access door and key lock.
 - c. Provide door-in-door construction with lockable latch fasteners on all doors. All latch components to be all-metal construction. When more than one fastener is required on a door, provide single operator handle with multi-point fasteners. Locks shall be keyed alike and match the existing standard keying system (Corbin Cabinet Lock TEU-1 or GE – 75.) Opening outer door should expose terminals and circuit breakers in a single operation.
- 3. Circuit Breakers and Fused Switches
 - a. UL interrupting rating labeled
 - b. Coordinate interrupting ratings with the Protective System Device Studies. Minimum ratings shall be as follows:

208Y/120V Panelboards	10,000 AIC symmetrical
480Y/277V Panelboards	14,000 AIC symmetrical
Fusible Panelboards	100,000 AIC symmetrical

- c. Circuit breakers shall be “bolt-in” breaker units with common trip on multiple pole breakers.
- d. Provide minimum of 20% spare breakers for lighting panels and 25% spare breakers for receptacle and equipment branch panels.
- e. Spaces shall be provided with bussing, device mounting hardware and steel knockouts in dead front.

Installation, Fabrication and Construction

- 1. Firmly anchor cabinets directly or with concealed bracing to building structure.
- 2. Mount 6' 6" above finished floor unless otherwise required. When not located directly on wall, provide support frame of formed steel channel anchored to floor and ceiling structure.
- 3. Panelboards rated for 400 and 600 amps shall accept 225 amp frame circuit breakers.
- 4. Verify space available with equipment sizes and code required working clearances prior to submitting shop drawings.
- 5. Furnish cabinets prime painted. Do not field paint factory-finished panelboard or equipment covers.

6. Locate in dedicated spaces. Coordinate project construction so piping, ducts, etc. are routed around dedicated spaces above and in front of panelboards per code.
7. Provide nameplates and directories.

T. Raceways

Basis of Design

This section applies to the design and installation of raceway systems.

Design Criteria

1. **PVC** (Rigid Non-Metallic Conduit): Direct burial and concrete encased.
2. **EMT** (Electrical Metallic Tubing): Interior locations where not subject to physical damage; homeruns where additional future circuits are anticipated.
3. **IMC** (Intermediate Metal Conduit): Not for use in earth or embedded in concrete.
4. **RGS** (Rigid Metallic Conduit): All raceways in the Power Plant, utility tunnels, and in areas subject to physical damage.
5. **FMC** (Flexible Metal Conduit): Final connections to devices and equipment; use liquid-tight type for damp locations.
6. **IAC** (Interlock Armored Cable): Medium voltage cable rated for use in cable trays. Low voltage service conductors to buildings.
7. **MC** (Metal Clad) and **AC** (Armored Cable): Only for power and lighting branch circuits. Circuits shall be concealed and run from junction boxes to light fixtures and devices within the same room. Circuits shall not run horizontally around wall corners.
8. **SMR** (Surface Metal Raceway): Laboratory areas and similar applications.
9. **Wireways and Cabletrays**: Medium voltage and other special applications and special low voltage applications approved by Engineering Services. Design information for cable tray used for medium voltage systems and communications systems shall be provided separately for each system.
10. Other systems may be used with coordination and approval by Engineering Services.
11. Supplement all raceways with equipment grounding conductors.
12. Provide a raceway system for connection to campus distribution systems in the utility tunnels. This system may utilize either cable tray or conduit with large radius bends. If conduit is used, provide a 3-inch conduit for signal systems. For telephone, computers, and cable television systems, refer to UW Technology Design Guide.
13. Refer to MV sections for additional criteria when designing raceways for the primary distribution system.

Submittals

1. Provide standard industry submittal requirements.
2. Provide support information for SMR's (i.e. conduit to raceway transitions need to be a manufactured product not field modified), cable trays and wireways.

Products, Materials and Equipment

Use industry standards for raceway systems specified and comply with the following additional requirements:

1. All 45 degree bends and greater for PVC conduit in MV applications shall be rigid metallic conduit.
2. Rigid metallic conduit shall be hot-dipped galvanized inside and outside.
3. EMT, indenter fittings are not acceptable.
4. SMR shall be dual channel type. Recommended SMR shall be formed steel type. Extruded Aluminum and plastic type may be considered for some applications with coordination and approval from Engineering Services. Connections to SMR shall be through manufactured fittings only.
5. Cable trays for medium voltage applications shall be ventilated, trough type. Side rails shall be rolled, with non-cutting edges.

Installation, Fabrication and Construction

1. Conduits placed in concrete slabs are not allowed except in special cases where no other means of routing is available. With prior approval from UW Engineering Services, conduits placed in concrete slabs are allowed in parking garages, storage facilities, and similar facilities.
2. Use of extension rings for junction boxes, splice boxes, and outlet boxes, in new construction, is not allowed.
3. Generally, conceal raceway systems. Exposed conduits are permitted only in unfinished areas, SMR systems in laboratory areas, and where approved by the Architect.
4. Provide expansion fittings for conduits passing through building construction expansion joints.
5. Wiring above hard lid ceilings shall be in conduit.

Cable Trays

6. For medium voltage systems, cable trays shall hold only one cable circuit each. Exceptions are allowed on a case-by-case basis and only with the approval of UW Engineering Services. Tray-dividing barriers shall be provided when more than one cable circuit is installed in the same tray. This barrier shall be at least as tall as the medium voltage cable diameter and securely fastened to the tray. Provide a 500kcm ground cable the length of the tray. Bond to every tray section and ground rod at every vault.
7. Provide an appropriate sized ground cable the length of the tray. Bond to every tray section and conduits that have wiring going to the tray.
8. Provide low voltage cable tray distribution system for use by all low voltage systems except fire alarm and nurse call on each floor. In general, cable tray shall be installed in building corridors above suspended ceilings except in cases where the plenum space is used for air handling. In the latter case, consider installation of cable tray below finished ceiling.

U. Switchboards

Basis of Design

This section applies to the design relating to low voltage switchboards.

Design Criteria

1. UW Class N1 facilities main switchboards shall be rear accessible. The main, tie and feeder breakers shall be of the drawout airframe type construction.
2. UW Class N2S facilities main switchboard(s) shall be rear accessible. The main and tie breakers shall be of the drawout airframe type construction. Feeder breakers shall be individually mounted, compartmentalized molded case circuit breakers. Feeder breaker sizes in the main switchboard shall be limited to the minimum ampacity breaker that can be provided with ground fault protection integral to the breaker electronic trip unit (not an external add-on accessory).
3. UW Class N2P facilities main switchboard shall be rear accessible. The main breaker shall be of the drawout airframe type construction. Feeder breakers shall be individually mounted, compartmentalized molded case circuit breakers. Feeder breaker sizes in the main switchboard shall be limited to the minimum ampacity breaker that can be provided with ground fault protection integral to the breakers electronic trip unit (not an external add-on accessory). Provide provisions for a temporary generation connection to the main switchboard. This can be provided by a molded case switch (similar to a molded case breaker but with no overload protection) or some sort of bus connection point. This connection shall be downstream of the switchboard main breaker in order to isolate the transformer.
4. UW Class N3 services building switchboard shall be front accessible and utilize group mounted thermal-magnetic molded case circuit breakers.
5. For UW Class N1, N2S and N2P service building switchboards: Provide electronic trip units with long time, short time and ground fault (LSG) protection (for both the draw-out air frame and molded case circuit breakers). Instantaneous protection shall not be provided since it limits coordination with downstream molded case circuit breakers. Two and preferably three levels of ground fault protection are desired. Selectivity is critical to the University in order to limit the extent of power outages.

Submittals

1. Catalog cuts including equipment ratings, dimensions, and installation instructions
2. Listing by manufacturer standards

Products, Material and Equipment

Approved Manufacturers - Switchboards

1. GE

2. Siemens
3. Cutler Hammer

Approved Manufacturers – Network Relays

1. Electronic Technology Incorporated (ETI)
2. Cutler Hammer MPCV relays
3. Other manufacturers shall be pre-approved during the design phase.

General

1. NEMA PB-2 and UL 891 design equipped with hinged and latched rear access panels and hinged front panel for breaker and metering compartments.
2. The main bus shall run continuously through the switchboard and shall include a fully rated neutral conductor, which shall be insulated from the switchboard frame and supported in the same manner as the phase conductors.
3. Insulated and isolated silver-plated copper busing.
4. Provide copper ground through each vertical section.
5. Bus and connecting stabs for individual breakers shall be sized for the full capacity of the breaker frame size and not for the trip setting of the overcurrent devices. Provide protective shutters for the bus isolation when the breaker is removed. Provide fully rated vertical and horizontal bus sections.
6. Completely isolate the outgoing feeder cable terminal compartment from the main bussing, using suitable insulating type barriers. Locate at the rear of the structure, vertically aligned facing rear of section.
7. Provide terminal strips for remote control, metering and status features in an accessible cubicle. Neatly dress all control wire (horizontally and vertically) in an enclosed channel (with removable cover) or surface mounted raceway.
8. Main devices requiring energy for operation shall be supplied power from integral bus taps or stored mechanical energy devices.
9. Provide automatic “source select” scheme to ensure continuous control power to trip units and electronic meters. Provide terminals for access to the future secondary tie control power.
10. Provide Mimic labeling on the front surface of the switchboard showing the bussing arrangement. This labeling should reflect the equipment’s one-line diagram. Include transformer and breaker representations.
11. Flexible braided connectors to transformers.
12. Breaker lifting device mounted on rails.
13. Spaces shall be totally equipped to accept future carriages and feeder breakers without any outages.
14. Series rated equipment is not acceptable.

Breakers

1. Drawout circuit breakers must match existing campus equipment at that location. Minimum breaker size shall be 1600 amps.

2. Provide a breaker programmer Test Kit (one required per project).
3. Solid state protective devices shall provide long time, short time, ground fault trip (LSG). Current sensing shall be true RMS current. Manufacturer: G.E. MicroVersaTrip PM, Cutler Hammer OPTIM 1050 or approved equal. The unit shall also provide full trip function test, without tripping the breaker, with the breaker either in the energized or de-energized mode. The four-digit alphanumeric display shall indicate the following:
 - a. Cause of trip,
 - b. Instantaneous value of maximum phase and ground currents,
 - c. Approximate level of fault current that initiated an automatic trip,
 - d. Cause of trip LED shall remain illuminated if all power is lost to the breaker.
4. Main breakers shall have electrically operated closing features for remote and automatic operation.
5. Tie and feeder breakers shall be drawout breaker similar to main, without electrical operation.

Network Protection Systems

1. Refer to attached drawing, [Typical Network Control Schematic](#) as a guide for designing systems with network protection. Network protection equipment, devices, and operation shall comply with the requirement below and with the attached drawing and shall be included in the design documents. Deviations from this typical design and construction shall not be allowed unless approved by UW Engineering Services.
2. Consists of drawout power circuit breaker with electrical motor-charged mechanism closed and tripped by network relays for reverse current or undervoltage. AIC, frame and trip settings shall be provided by the drawings and verified by the protective device study.
3. Relays shall, at a minimum, consist of a master-relay (a three-phase directional relay designed to provide highly sensitive directional tripping and to close the circuit breaker if the network voltage is favorable) and a phasing relay which permits breaker closing only when the phasing voltage lags the network voltage by up to 25 degrees or leads it by up to 100 degrees. The network relays function to automatically close the breaker only when voltage conditions are such that its associated transformer will supply load to the secondary loop, and to automatically open the breaker when power flows from the secondary loop to the network transformer.
4. Provide rotary cam switch for manual-off-auto of network protection. Switch shall be manufactured by Electro-Switch Series 24 or an approved equal. (Typical switch characteristics: Heavy duty, rotary switch, UL listed, CSA certified, ESC standard 1000 compliance, ANSI/IEEE 323 compliance, IEEE 344-1975 compliance.)
 - a. Manual position: The electrically operated main breaker should be allowed to recharge but not to reclose. Reclosure shall be operator-initiated and only allowed if the network relays determine the closure is acceptable.
 - b. Off position: Network protection is inoperable.
 - c. Auto position: The network protection control relays should fully control the auto reclosure of the main breaker.

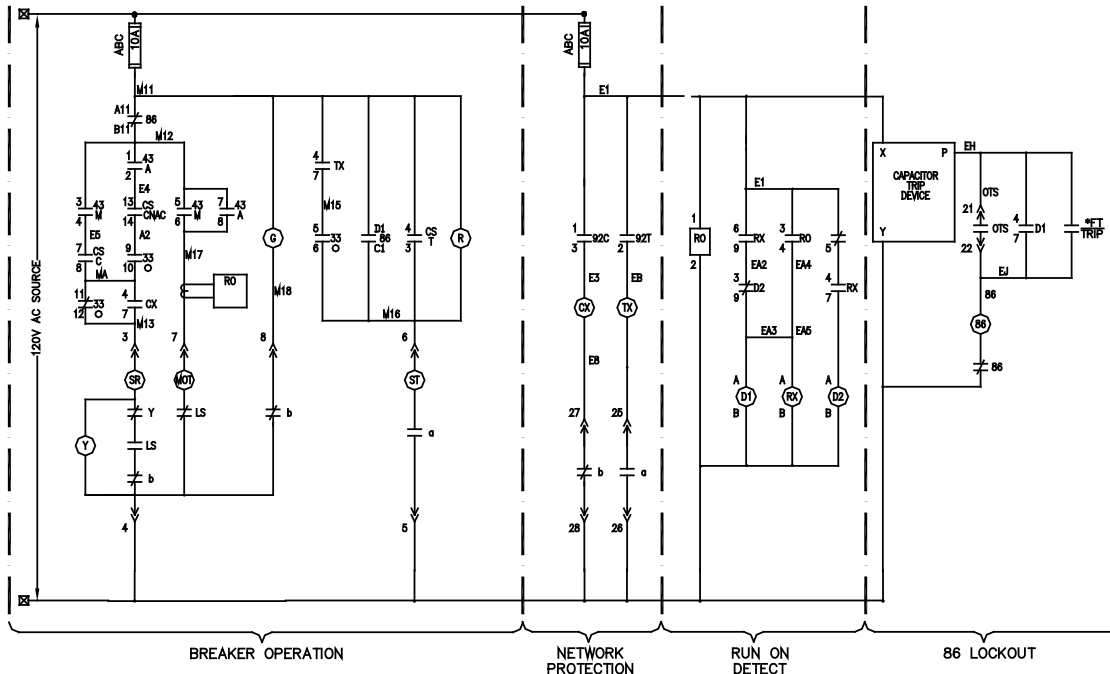
5. For proper operation, network relaying shall work in conjunction with a stored energy device (86 relay). This locks the main breaker out from automatically reclosing after an overcurrent, short circuit or ground fault condition.
6. Current sensing shall be true RMS current.
7. Load demand reclosure controls as found on public utility networks should not be used. Reclosure should be permitted when the network voltages are correct and in proper rotation. Recloser will limit the number of breaker closure attempts to 3.
8. Network protection relays shall be mounted on a base that allow the relay to be racked out for testing and maintenance. The relay shall operate in test mode in the racked-out position.

Control Power

1. Refer to attached drawings [Typical Network Control Power Schematic](#) as a guide for designing network protection control power. Network control power shall comply with the requirements below and with the attached drawing and shall be included in the design documents. Deviations from this typical design and construction shall not be allowed unless approved by UW Engineering Services.
2. For spot network and double-ended substations, provide relays and interlocking so that control power is available if one or more transformers are energized. Provide automatic "source select" scheme to ensure continuous control power to all breaker trip units, switchgear controls and electronic metering. Control power shall be derived from connections ahead of the main breaker(s).
3. Provide emergency power for electronic meters and primary switch position monitoring contacts to ensure they operate during outages and during feeder switching operations. Emergency power shall be for electronic meters only and shall not be used to provide continuous control power for trip units and switchgear controls. Switchgear control power shall be derived using the "source select" scheme, mentioned above, ahead of the main breaker(s).

Installation, Fabrication and Construction

1. Leveling rails are required for drawout equipment to insure proper alignment.
2. Installation is not complete until all electrical & mechanical tests are performed and passed.



NORMAL CONDITION

BREAKER OPEN AND RACKED OUT

DEVICE LEGEND

33	TRUCK OPERATED SWITCH. CONTACTS CHANGE STATE WHEN CIRCUIT BREAKER ELEMENT IS REMOVED FROM ITS CELL OR IN TEST POSITION.	CS	CONTROL SWITCH, BREAKER CONTROL: CS/C-CONTACT CLOSING IN "CLOSE" POSITION. CS/T-CONTACT CLOSING IN "TRIP" POSITION. CS/NAC-CONTACT CLOSING IN "OFF" POSITION WHEN SWITCH WAS PREVIOUSLY IN "CLOSE" POSITION (NORMAL AFTER CLOSE; PERMISSION TO GO IN AUTO MODE).
43	CONTROL SWITCH, FOR MODE OF BREAKER OPERATION: 43/A-RELAY AUTOMATIC CONTROL OF BREAKER. 43/M-OPERATOR MANUAL CONTROL OF BREAKER. 43/O-NO OPERATION OF BREAKER ALLOWED.	CX	CLOSE COIL.
86	LOCKOUT RELAY.	D1	RUN ON DETECT TRIP.
92	NETWORK PROTECTION RELAY.	D2	RUN ON DETECT TIMER.
*	BREAKER IDENTIFICATION SUCH AS M1, F1, T1, ETC.	LS	LIMIT SWITCH CONTACT, OPERATES WHEN SPRING CHARGING MOTOR HAS FULLY CHARGED THE OPEN AND CLOSING SPRINGS IN THE BREAKER.
* a	BREAKER AUXILIARY CONTACT SWITCH, EACH CONTACT CLOSING WHEN CIRCUIT BREAKER IS IN CLOSED POSITION.	MOT	MOTOR, MECHANICALLY CHARGES THE OPEN AND CLOSING SPRING IN THE BREAKER.
* b	BREAKER AUXILIARY CONTACT SWITCH, EACH CONTACT CLOSING WHEN CIRCUIT BREAKER IS IN OPEN POSITION.	RO	RUN ON DETECT RELAY. APPROVED: SSAC PART # ECS41BC
* FT	TRIP CURRENT LIMITER (POWER FUSE) CONTACT WHICH CHANGES STATE WHEN ONE OR MORE LIMITERS OPEN.	Rx	RELAY AUXILIARY CONTACT, RUN ON DETECT.
* OTS	OVERCURRENT TRIP SWITCH, EACH CONTACT CHANGES STATE, WHEN BREAKER IS TRIPPED DUE TO GROUND FAULT, SHORT CIRCUIT, OR OVERLOAD.	SH TR	SHUNT TRIP COIL. OPERATES OPENING MECHANISM TO OPEN CIRCUIT BREAKER.
		SR	SPRING RELEASE COIL. OPERATES CLOSING MECHANISM TO CLOSE CIRCUIT BREAKER.
		TX	TRIP COIL.
		Y	ANTI-PUMP COIL, OPERATES WHEN A SIMULTANEOUS OPEN AND CLOSE SIGNAL ARE PRESENT. ANTI-PUMP PREVENTS CYCLING OF BREAKER.

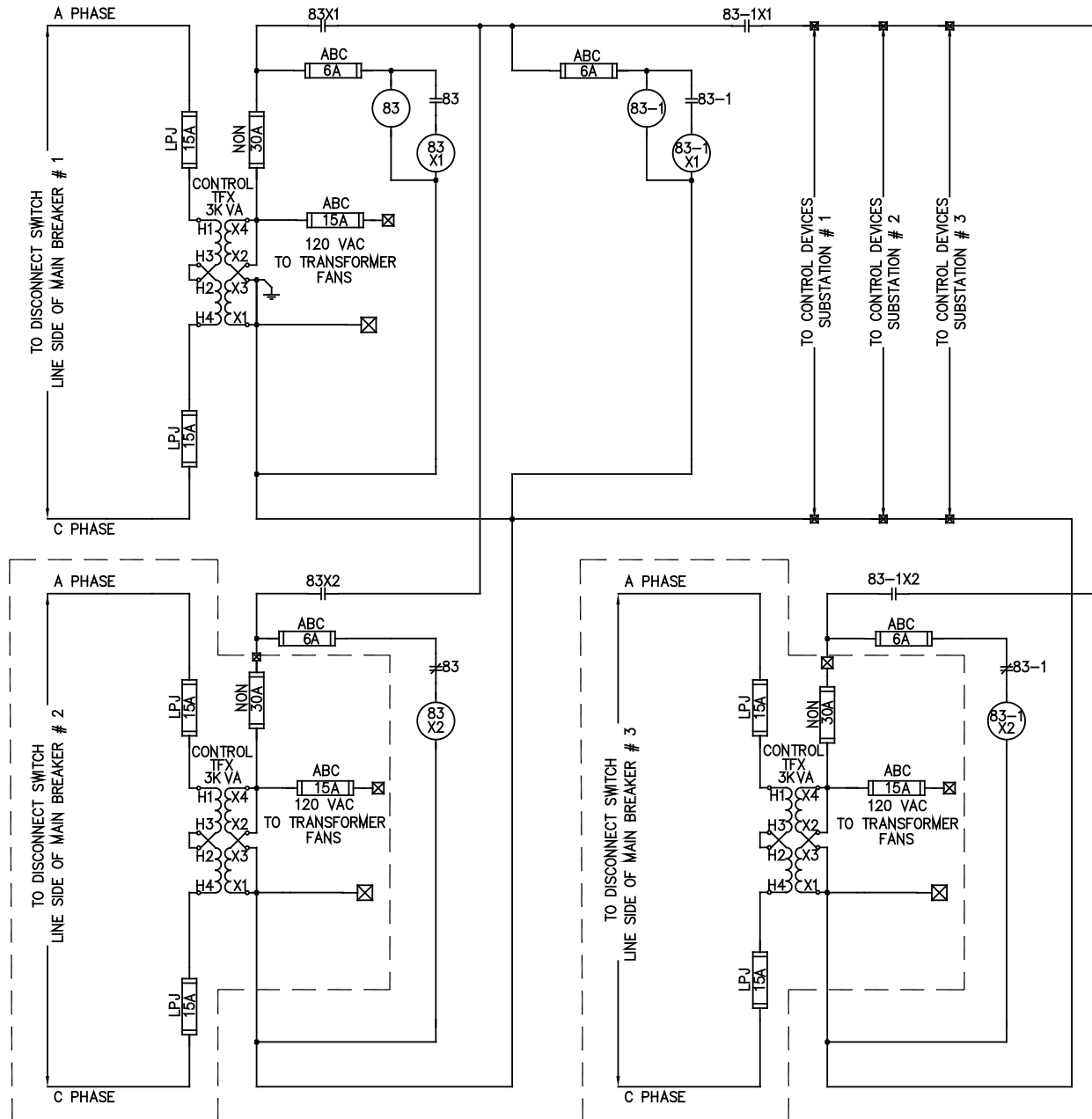
OPERATION SEQUENCE

NETWORK PROTECTION TRIP IS OPERABLE IN ANY MODE. NETWORK PROTECTION (NP) IS INOPERABLE WHEN BREAKER IS IN THE UNCONNECTED POSITION. PER PROTECTIVE DEVICE STUDY NP IS ALSO SET TO TRIP ON REVERSE MAGNETIZING CURRENT OF THE TRANSFORMER SERVED (REQUIRES AT LEAST 50 AMPS OF SWITCHBOARD LOAD)

RUN ON DETECT SENSOR (RO) TRIPS (D1) WHEN RUN ON DETECT TIMER (D2) EXCEEDS SET TIME.

CAPACITIVE TRIP DEVICE PERMITS LOCKOUT (86) FUNCTION WITHOUT CONTROL POWER AVAILABLE.

SD-E-169



CONTROL POWER TRANSFER SCHEME

SD-E-123

V. Commissioning Support

Basis of Design

This section applies to the requirements for electrical commissioning support.

For the Electrical Commissioning Support [Standard Specifications click here](#).

Design Criteria

1. Refer to the Electrical Commissioning Support standard specifications and modify as required, to meet the project requirements.
2. Close coordination is required during the development of the construction schedule to ensure design documents stipulate electrical installation, testing, and calibration for electrical equipment shall be completed prior to the start of the commissioning process.
3. Stipulate in the design documents the requirement for electrical contractor to provide support for all commissioning activities. Electricians and technicians necessary for commissioning procedures shall be available on site.
4. Refer to Mechanical Commissioning specifications to determine scope of electrical commissioning work. Ensure that electrical equipment and systems are included in the commissioning scope. The commissioning scope shall include the following systems:
 - a. Verify and document that electrical inspection, calibration, and testing requirements specified in section 16CC are complete.
 - b. Functional operation of the emergency power systems including generators and automatic transfer switches (ATSs). Include power outage simulation, start-up and transfer of power to the emergency system, operation of loads connected to the emergency system, start-up and shut-down of equipment related to:
 - i. Fire Alarm System,
 - ii. Electrical distribution systems,
 - iii. Motor control centers and starters,
 - iv. Variable frequency drives.
 - c. Lighting systems – check for proper lamp types, reflectors are adjusted and performing as specified, design lighting levels are met, and spot checks of ballast factors.
 - d. Lighting control systems – Check to ensure system are programmed as designed and maintenance personnel are provided with training and manuals to reprogram the system as use and operation of the building changes.

Submittals

Refer to Electrical Commissioning Support standard specifications.

Installation, Fabrication and Construction

Refer to Electrical Commissioning Support standard specifications.

W. COMMISSIONING SUPPORT – STANDARD SPECS

STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. 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 26 00 00 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 26 00 00 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 26 08 00 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 26 00 00 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,

- g. Providing assistance to the Test Engineer to develop and edit system operation descriptions,
- h. 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 01 GENERAL REQUIREMENTS.
- B. All start-up and testing procedures and documentation requirements specified within Division 26 00 00.
- C. All Division 26 08 00 commissioning procedures that require participation of Division 26 00 00.

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
 - 3. American Society for Testing and Materials - ASTM
 - 4. Institute of Electrical and Electronic Engineers - IEEE
 - 5. American National Standards Institute - ANSI
 - 6. National Electrical Safety Code - C2
 - 7. State and local codes and ordinances
 - 8. Insulated Power Cable Engineers Association - IPCEA
 - 9. Association of Edison Illuminating Companies - AEIC
 - 10. Occupational Safety and Health Administration - OSHA 29CFR Part 1910.269
 - 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
 - e. ANSI/NFPA 101: Life Safety 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 26 00 00 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 26 00 00 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 26 00 00 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 26 00 00 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 26 00 00 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 00 00.
 - 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 26 00 00 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 01 and 26 08 00, 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 01, 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 26 00 00 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 01.
 - 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 26 00 00 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.

X. Grounding

Basis of Design

This section applies to the design and installation of electrical grounding.

Design Criteria

1. Use the UFER grounding philosophy when designing grounding systems.
2. Provide all grounding for electrical systems and equipment, including but not limited to:
 - a. Service neutral,
 - b. Raceway systems,
 - c. Switchboards and panelboards,
 - d. "Separately derived system" (transformer or emergency power supply),
 - e. Electrically operated equipment and devices.
3. Ground bus is preferred in the main electrical room.
4. Provide additional grounding requirements for hospital distribution systems when required.
5. Provide additional grounding requirements for computer systems and other electrical noise-sensitive equipment when required.
6. Provide lightning protection system requirements when required.
7. Review grounding for the primary distribution system.

Products, Materials and Equipment

1. Grounding conductors shall be copper only. Use bare or green insulated in sizes #10 AWG or larger. Use green insulated for size #12 AWG.
2. Ground rods shall be $\frac{3}{4}$ " x 10' 0" copper clad steel.
3. Ground connections and ground cable splices that are accessible for maintenance and repair shall be thermal welding or copper compression set type connectors UL listed for grounding purposes. Ground lugs, where provided as standard manufacturer's items on equipment furnished, may be used.
4. All ground connections underground or inaccessible for maintenance and repair shall be thermal welding only. Compression connectors are not allowed.

Installation, Fabrication and Construction

1. All branch circuits shall include a ground wire connected between the branch circuit panelboard ground bus and the wiring device or equipment ground terminal that the branch circuit serves. One ground wire in each branch circuit raceway, looped between ground terminals, is required.
2. Where ground wire is exposed to physical damage, protect with rigid non-ferrous conduit as permitted by applicable code.
3. In conduit runs requiring an expansion fitting, install a bonding jumper around the fitting to maintain continuous ground continuity.

4. Protect ground cables crossing expansion joints or similar separations in structures or paved areas from damage by means of suitable approved devices or methods of installation which will provide the necessary slack in the cable across the joint to permit movement.
5. Provide a grounding bushing with #10 ground conductor (or larger when required by code) to the grounding bus in the panelboard and switchboards.
6. See [electrical VFD section](#) for grounding requirements.

Y. Inspection, Calibration, and Testing

Basis of Design

This section applies to the requirements for electrical inspection, calibration, and testing.

For the Inspection, Calibration, and Testing [Standard Specifications click here](#).

Design Criteria

1. Edit the Inspection, Calibration, and Testing standard specifications, as required, to meet the project requirements.
2. All inspection, calibration, and testing of electrical equipment shall be completed prior to the start of the commissioning activities. Ensure this is accounted for in the design schedule.

Submittals

Refer to Inspection, Calibration, and Testing standard specifications.

Installation, Fabrication and Construction

Refer to Inspection, Calibration, and Testing standard specifications.

Z. INSPECTION, CALIBRATION, AND TESTING – STANDARD SPECS

STANDARD SPECIFICATIONS

This standard specification is intended to be integrated into the project specifications. 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 01 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.
 - a. International Electrical Testing Association – NETA
 - b. National Electrical Manufacturer's Association – NEMA
 - c. American Society for Testing and Materials – ASTM
 - d. Institute of Electrical and Electronic Engineers – IEEE
 - e. American National Standards Institute – ANSI
 - f. National Electrical Safety Code - C2

- 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
 - q. ANSI/NFPA 101: Life Safety 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's 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 seven (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 Engineer.
- 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 26 00 00.
- 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):

Insulation Voltage Class	Acceptance Voltage	Maintenance Voltage
	<i>New Cable</i>	<i>Cable age > 10 years</i>
15kV AC	35kV DC	16kV DC
5kV AC	15kV DC	2.5kV DC, Megger for 10 minutes

*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 23 00 00 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 tested 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 the Switchboard section. 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. The main breaker should charge but not close.
 - (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: 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.
- 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.

AA. Lighting

Basis of Design

This section applies to the design and installation of lighting systems.

Design Criteria – Interior Lighting

1. Seattle Energy Code prescriptive measures need to be discussed with UW Engineering Services.
2. Average luminaire efficiency to be greater than 75% for the entire interior lighting system. Use white reflecting surfaces with a total reflectance greater than 88% and anodized aluminum reflecting surfaces with a total reflectance greater than 93%.
3. LED luminaires are required to be vetted by the Design Light Consortium (DLC or Energy Star).
4. Custom or special order fixtures need Engineering Services approval.
5. Use realistic maintenance factors based on products actually used.
6. Do not use proprietary drivers.
7. Verify radio frequency-sensitive areas meet FCC CFR 47 Part 18 class B requirements and/or provide luminaires with sufficient RFI shielding, including shielded lenses and high integrity ground bonding.
8. Coordinate with the architect so the lighting system can be maintained. Access to the luminaires must be considered in design.
9. Evaluate luminaire equipment access (e.g. require that personnel bring equipment such as ladders or lifts).
10. Review with consultant/contractor during luminaire selection installation and maintenance approaches.
11. Laboratory Lighting: Provide egress lighting on emergency power near door inside of wet and large laboratories.

Design Criteria – Exterior Lighting

1. Do not use uplights or bollards for landscape lighting unless approved by Engineering Services and the UW Landscape Committee.
2. In general, pathway lighting in the UW Seattle campus is required to match the performance and appearance of the Archetype series AR/SAR by KIM lighting. Other types of light fixtures will need review and approval by the UW Landscape Committee.
3. Protect all street and walkway luminaires with waterproof in-line fuse holders located in each pole base.
4. Fuses are required to be on the line side of the driver.
5. Repair or module replacement is required to be accomplished quickly and without tools. The entire module is required to snap out without tools, and to include quick-disconnect plugs on all wiring. Allow for a new module to be quickly inserted to eliminate downtime.

6. The lens frame is required to be removable without tools, providing easy lens replacement in the event that breakage occurs. Require the door frame to be prevented from lifting out of its hinges when hanging in the down position.
7. Luminaires are required to fit, or to be completely adaptable, to existing poles utilized on campus.
8. All fixtures are required to be grounded and finished to the final mounting surface (e.g. shrouds used so animals cannot enter the pole).

Average Maintained Foot-candles at Work Surfaces

- 70 Laboratories, drafting rooms
- 50 Paperwork-intensive offices, shops, kitchens, library study areas, etc.
- 35-42 Classrooms, lecture rooms, classroom auditoriums, computer-oriented offices and general-purpose computer work stations/labs. Consider two-level switching (50/17fc.) for mixed computers and paperwork.
- 30 Non-classroom auditoriums, conference rooms
- 20 Restrooms, mechanical and electrical rooms, locker rooms, etc.
- 10 Special computer labs: Consider two-level switching (30/10fc.) for mixed uses.

Minimum Maintained Foot-candle:

- 15 Corridors, passageways and stairways adjacent to spaces with more than 50 foot-candles
- 10 Corridors, passageways, stairways, storerooms, etc.
- 2.5 Covered parking garages (Coordinate with UW Transportation Services and UW Police for security recommendations)
- 1 Open parking
- 1 Roadway
- 0.5 Walkways

Submittals

1. Verify with consultant/contractor during luminaire selection installation and maintenance approaches.
2. Include in shop drawings a table of luminaire/driver compatibility.
3. Submit point-to-point calculations with electrical close-out documents.
4. Shop drawing as-builts are required for final delivery to UW Records.

Products, Material and Equipment

1. Mount flat lenses in frames designed for replacement with lenses up to .38 inch thick.
 - a. Use clear plastic lenses that are 0.125 inch minimum thickness virgin acrylic.
 - b. Use pattern 12 lenses where a diffuse light source is desired.
 - c. Pattern 15 lenses are preferred to minimize imaging on video monitors.
 - d. Use sealed luminaires with Corning pattern 79 glass lenses in sterile areas.

2. Sockets and screw in base luminaires are preferred.
3. Supply luminaire parts with internal disconnects. Sta-Kon disconnects by Thomas & Betts, Cat. No. LD-2, or equal are required.
4. Defective parts replacement by manufacturer is required for 10 years from the date of purchase.
5. Provide 10% spare for each fixture type.

Illuminated Exit Signs

1. Compliance with UL 924 and EPA EnergyStar Specifications at the end of 5 years of continual use.
2. Green is the preferred lettering color.

Installation, Fabrication and Construction

1. Design louvers and lenses to open easily, hang open from the luminaire, and be removed from the luminaire, all without the use of tools.
2. Review installation and maintenance approaches with UW Engineering Services.

BB. Lighting Control

Basis of Design

This section applies to the design and installation of lighting control systems.

Design Criteria – Interior Lighting

1. Centralized and networked control systems are required.
2. Provide data connections as required to the FacNet system.
3. Automatic controllers and time clocks are required. Maintain time and schedule through a 72-hour power failure.
4. Provide BacNet connection to the Building Automation System (BAS).
5. Implement zone control for common areas.
6. Lighting control software or application shall be stored on a central server provided by the UW.
7. Provide Graphics User Interface to show light fixture status and remote programming.

Design Criteria – Exterior Lighting

1. Pathway and roadway lighting shall be connected to the "UW Cascade system".
2. All exterior lighting shall be controlled by NEMA rated contactors. Include an "Auto-On-Off-Manual" selector switch.
3. Homeruns shall be 1.5" conduit, minimum.

Submittals

1. Provide MAC Addresses for all equipment requiring data connections.
2. Provide documentation of the final commissioning report for lighting control.

Products, Material and Equipment

Interior/Classroom Lighting Control Systems

1. Approved manufacturers for building network lighting control systems: Lutron, Legrand, nLight, Douglas.

Exterior Lighting Control Systems

1. Cascade Lighting Control System (Existing)

Installation, Fabrication and Construction

1. Review accessibility of lighting control panels and relays for difficult access spaces, such as vivaria, bio-hazard areas, operating rooms, patient rooms, and procedure rooms. Preferred locations are in the hallway outside of space.

2. Room controllers are to be located at the same location for each room (e.g. preferably by the door for access reasons).
3. Use effective and professional wire management approach (e.g. provide labelling for all wiring and terminations).
4. Locate photocells in protected accessible areas.
5. Conduit layout for controls allows for future changes to the operation of the light fixtures without having to install new conduit from lighting control panels. Size conduit for spare capacity to install additional control wires. Avoid “daisy chained” light fixtures.

CC. Motor Control and MCCs

Basis of Design

This section applies to the design and installation relating to motor control centers and motor control equipment.

Design Criteria

1. MCCs shall be standard manufacturer design and construction to permit ready installation, removal, or replacement of standard components.
2. Provide continuous metering for MCC breakers that will interface with the University's centralized EMMS system.

Submittals

1. Equipment catalog cuts
2. Dimensioned installation drawings

Products, Materials and Equipment

1. Approved Manufacturers
 - a. Eaton/Cutler Hammer
 - b. ABB/GE
 - c. Siemens
2. Construction shall be according to NEMA standards, with unit terminal strips only.
3. Starter units shall be the circuit breaker combination type.
4. Provide all motors with proper starting and overload protective devices. Provide overload protections in all three phases for three-phase motors, in all "hot" legs for single-phase motors.
5. Combination circuit breaker-type starters are preferred over separate components.
6. Full voltage starters shall normally be used. Provide reduced voltage starters in case of motors over 60hp, limited supply power, or unusual load characteristics.
7. Magnetic motor starters shall have Rotary Selector Switch "Hand-Off – Automatic" controls. This shall be for three-phase and single-phase motors. For motors without automatic control, the automatic position shall be left open.
8. Motor starter circuits shall provide demarcation terminals to allow others to introduce controls both before and after the HOA switch.
9. Manual position shall have no automatic controls except overload protection.
10. Use automatic position for any automatic control including freezestats, load shed, smoke control, remote manual control, and process control.
11. Automatic and manual positions shall have status contacts wired to the starter control terminal strip for smoke control fans and other critical motors.

12. Only intermittent, task-oriented motor starters shall have locally mounted “start-stop” push-button control (in addition to the starter HOA). If safety is a concern, local emergency stop buttons shall be provided.
13. Pushbuttons, selector switches, pilot lights bases, etc. shall be heavy-duty “oil-tight” devices.
14. Control circuits shall operate at 120 volts. 480-volt starters shall have internal control transformers; motor control centers AUG utilize a common control transformer if a control circuit fuse or breaker separately protects each unit.
15. Every control or remote pushbutton shall have an “ON” pilot light.
16. Provide red “ON” pilot light and “OFF” pushbutton.
17. Provide a green “OFF” pilot light and “ON” push button.
18. Pilot lights shall be LED type.
19. Motors over 20hp should have time delays on “restart after outage” to minimize inrush on start-up, and to prevent closing in on a back EMF. Provide staggered starting where necessary using adjustable relays.
20. Provide power factor correction capacitors for motors over 15hp. Power factor shall be corrected to 97%.
21. Electronic starters, following a power failure, shall automatically assume the mode that the starter was in before the power failure. To provide this for electronic starters, specifications need to state that electronic control modules shall provide this function.

Installation, Fabrication and Construction

1. Vertical wiring access shall be accessible from the front without opening individual control units, with hinged cover and captive screws.
2. Locate units away from high ambient temperatures and radiant heat sources.

DD. Power Quality

Basis of Design

Power Distribution

1. Provide a grounding conductor in all raceways for the primary grounding path. Raceways shall serve as the secondary ground path.
2. Segregate motor, equipment and lighting loads from power quality sensitive equipment and loads. Provide dedicated circuits for medical and research equipment that are sensitive to power quality.
3. Evaluate and specify the appropriate K-ratings for distribution transformers.
4. Many power quality problems in laboratories and similar facilities are related to equipment on receptacles that are on the same circuit. The Consultant shall take this into consideration when determining the number of circuits, the layout of receptacles on the same circuit and equipment requiring dedicated circuits.
5. Research Laboratories: Design shall meet the requirements of a research institution. At minimum provide a UFER ground system. An isolated ground system may also be required.
6. Provide easy accessible points of attachment to the building grounding system in the building main equipment room.
7. Evaluate and provide the following for laboratory bench circuits, computer circuits, sensitive equipment and panelboards as required:
 - a. Dedicated circuits,
 - b. Isolated grounds and isolated ground receptacles,
 - c. Transient surge suppressors,
 - d. Power conditioning,
 - e. Uninterruptible power supplies for critical loads.

Surge and Transient Protection

1. Provide distribution class surge arrestors on the building main transformer primary terminals to protect from surges and transients on the primary distribution system.
2. In some cases, transient surge protection in the branch circuit panelboards might be required. The focus should be on panels with dedicated circuits that have isolated grounding provisions.
3. Transient Voltage Surge Suppression – apply as needed. These devices are not a substitute for good wiring practices by the designer.

Lightning Protection

1. Lightning protection is to be installed where equipment or liability value is high. Consult with UW Engineering Services in determining if a lightning protection system is required. Lightning protection is typically required for the Medical Center, Health Sciences and high-tech science lab facilities.

2. Lightning protection systems shall conform to UL Code 96A (Lightning Protection Bulletin) and NFPA Code #78. The system shall be designed as a master label system.

Submittals

Develop submittal requirements for the appropriate specification sections.

Products, Material and Equipment

Develop requirements in the appropriate specification sections.

Installation, Fabrication and Construction

Develop requirements in the appropriate specification sections.

EE. Variable Frequency Drive Installations

Basis of Design

This section applies to the design of variable speed drive installations.

Design Criteria

VFDs can be a source of harmonics, which create system inefficiency and power quality problems. Perform studies and calculations to determine harmonic levels and, if required, specify harmonic filtering for VFDs.

Submittals

Provide standard industry submittal requirements.

Products, Materials and Equipment

Provide an individual conduit for each motor feeder being fed by a variable speed drive. The intent here is to provide isolation of the feeders so crosstalk between the feeders does not affect the operation of the variable speed drives.

Installation, Fabrication and Construction

1. Mount variable speed drives in individual enclosures that are appropriate for the environment where they are located.
2. Locate variable speed drives as close as possible to the motors they power to minimize motor feeder length. Maximum feeder length shall be 50 feet.
3. Provide continuous ground from the VFD to the motor makeup terminals.
4. Ground motor frame to the closest structural member.

FF. Wiring Devices

Basis of Design

This section applies to the design and installation of wiring devices.

Design Criteria

1. Provide 120V receptacles in janitor closets, toilet rooms, corridors, tunnels and other special purpose spaces for maintenance use.
2. In corridors, receptacles for cleaning shall be provided at spacing not to exceed 50 linear feet, near hallway intersections and rear entry vestibules. Circuits shall be separate from office and lab circuits.
3. In general, each circuit's overcurrent device should be on the same floor as the outlets.
4. Provide at least one 120V emergency receptacle in mechanical, electrical and communications rooms, connected to the building standby emergency panel.
5. Provide ground fault circuit interrupter (GFCI) receptacles as dictated by good engineering practice. Use master/slave arrangement. Reset must be accessible by users.
6. Review designation required by the SEC for switched receptacles.
7. Review floor boxes per project application

Products, Materials and Equipment

1. Use specification-grade self-grounding devices. Use hospital-grade receptacles and attachment plugs for health care facilities and laboratories.
2. AC only "quite" type switches, 20 ampere rating, self-grounding. Ivory color for normal power, red for emergency. Interchangeable type devices may be used only for special applications when approved by Engineering Services.
3. Use neon or low voltage transformer-base pilot lights for long life and ruggedness.
4. Device plates shall be stainless steel in finished areas, galvanized or cast to suit boxes in areas where exposed wiring is permitted.

Installation, Fabrication and Construction

Use hard ground pigtails. Do not rely on a device's self-grounding feature.

GG. Miscellaneous Signal Systems

Basis of Design

This section applies to the electrical design requirements relating to miscellaneous controls and signal systems.

Design Criteria

1. Coordinate design requirements for the following systems:
 - a. Clock and centralized system interface,
 - b. Alarms and remote monitoring,
 - c. Electrically operated windows and shades,
 - d. Automated whiteboards and projection screens.
2. All systems shall be designed to utilize modern equipment and shall be arranged to provide flexibility, ease of expansion, and accessibility.
3. Provide low voltage cable tray distribution system for use by all low voltage systems. Coordinate with [Electrical Raceway section](#).
4. Identify spaces for terminal equipment required for miscellaneous signal systems. Coordinate with the mechanical designer to provide adequate cooling in the spaces.
5. When required, a raceway system shall be provided for connection to campus distribution systems in the utility tunnels for miscellaneous signal systems.

Submittals

1. Require operating manuals, manufacturer one-lines, and manufacturer equipment and raceway size calculations.
2. As-built drawings.

Products, Material and Equipment

1. Clocks – provide Simplex 4 wire.

Installation, Fabrication and Construction

1. Clocks - provide flush mount back boxes.

Preferred Vendors and Products - Electrical

Product	Manufacturer A	Manufacturer B	Manufacturer C	Manufacturer D	Remarks
CMCS system	Allen Bradley PLC-based	Allen Bradley IAS			No substitutions
generators 175kw and larger	Caterpillar				No substitutions
generators smaller than 175kw	Caterpillar	Onan	Kohler		Or approved equal.
transformers	ABB	Square D	GE	Siemens	Or approved equal.
TV monitor and camera backbox	Steel City #H2-BD-3/4 1 and #2-GC				Or approved equal.
MV connections & terminations	Raychem HVT	3M Quick Term series 5600			Or approved equal.
Splices other than cold shrink	OZ Gedney Series SPKJR	G&W #E74	Adalet 3AS (PLM)		Or approved equal.
MV connections & terminations	3M	Elastimold			Or approved equal.
Approved manufacturers	ASCO-Delta	Russelectric	Cutler Hammer		Or approved equal.
Power circuit breaker	Cutler Hammer Vacuum Breakers (VCP-W) no exceptions				No substitutions
Electrical Vaults	Utility VaultCo	Renton Concrete Products	Fog-tite	Quasizte	Or approved equal.
Primary Switch	S & C				No substitutions
Transformers	ABB	Square D	GE	Siemens	Or approved equal.
Local Data Collection Controller	See Standard Specifications				No substitutions
Service Meter	See Standard Specifications				No substitutions
Sub-Meter	See Standard Specifications				No substitutions
SCADA - Multi-Channel Isolated Digital I/O Modbus TCP Module	Advantech e.g. ADAM-6050				No substitutions
test block	GE type PK-2 #6422120G3; type PK 2 #6422420G4	Marathon 1500	Buss #15149-3		No substitutions
Switchboards	GE	Siemens	Cutler Hammer		Or approved equal.
Network Relays	Electronic Technology Inc (ETI)	Cutler Hammer MPCV	Other manufacturers shall be approved during the design phase		No substitutions
Breakers	GE MicroVersaTrip PM	CH OPTIM 1050	or approved equal		Or approved equal.

Preferred Vendors and Products - Electrical

Product	Manufacturer A	Manufacturer B	Manufacturer C	Manufacturer D	Remarks
Panelboards	CH	GE	Siemens		Or approved equal.
cabinet locks	Corbin TEU-1	GE 75			Or approved equal.
Transfer switches - for UW Class E1 & E2 emergency services	Russoelectric				No substitutions
Transfer switches - for UW Class E3 & E4 emergency services & outlying campuses	Russoelectric				No substitutions
Features and Accessories part #	18 specific Russelectric Items				No Substitutions
Switchboards	CH	GE	Siemens		Or approved equal.
					See FSDG Section 15G in "Mechanical" sheet.
Switching Systems					No Substitutions
Centralized	Creston	Douglas	Lutron		No Substitutions
Clocks	Simplex cat# 6310-9231				No substitutions
Bells	Simplex cat# 2902-9501 buzzers				No substitutions
Intercom	3M	Pamex	Valcom		Or approved equal.
Nurse call systems	shall match existing and / or approved by UWMC ops & maintenance				No substitutions
Paging	TOA	Dukane			Or approved equal.
Room Control System	AMX				Or approved equal.
audio mixers / amplifiers	TOA 900 preferred by classroom services				Or approved equal.
Electrical Engineering Firm for Power System Studies	Power Systems Engineering	Siemens Technical Services	Washington Group International, Inc.	Electrotest Inc.	Or approved equal.
Software for short circuit study	SKM Power Tools for Windows				No substitutions
Software for coordination study	SKM Power Tools for Windows				No substitutions
Electrical Testing Contractor	Siemens Technical Services	Sigma 6	Electrotest, Inc.		Or approved equal.