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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. Provide WiFi connection and cell service in all electrical rooms. See the UW-IT Design Standards for service requirements.
9. See Architectural Finishes section for coating of floors above electrical rooms.
10. 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 and in 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.

4. Do not install equipment in difficult to access locations. If unavoidable, see the Maintenance Access Plan for Hazardous Spaces section of the Requirements Common to All Disciplines and Projects document.

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 Standards.

   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 –20º to +40º C (0 to 105º 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 the Metering & Monitoring 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.

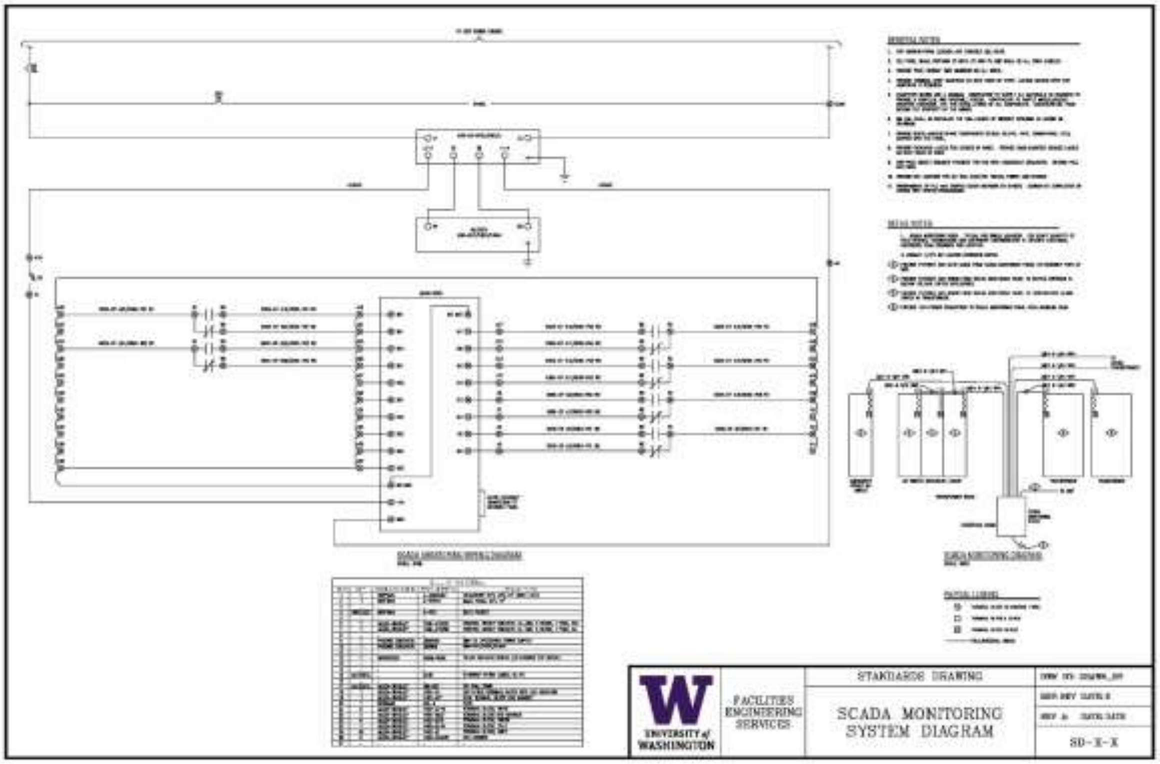
2. Mounting and electrical connections

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


UNIVERSITY of WASHINGTON
FACILITIES ENGINEERING SERVICES
STANDARDS DRAWING
SCADA MONITORING SYSTEM DIAGRAM
SD-X-X

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, Materials and Equipment

1. Russelectric, ASCO, or approved equal:
   a. UW Class E1 and E2 emergency services.
   b. Bypass/Isolation (BIS) style transfer switches.
2. Russelectric, ASCO, or approved equal:
   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. 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 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 pigtails 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.

G. Medium Voltage Wire, Cables and Terminations

Basis of Design

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

For the MV Wire, Cable and Terminations Standard Specifications click here.

Submittals

For medium voltage systems, refer to MV Wire, Cable and Terminations Standard Specifications.

Products, Materials and Equipment

See Preferred Manufacturer List.

Installation, Fabrication and Construction

1. See Preferred Manufacturer List.
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.

H. 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.

I. Dry-Type, Medium Voltage Transformers

Basis of Design

This section applies to the design and installation relating to Dry-Type, Medium Voltage Transformer.

For the Dry-Type, Medium Voltage Transformer Standard Specifications click here.

Submittals

For medium voltage systems, refer to the Dry-Type, Medium Voltage Transformer Standard Specifications.

Products, Materials and Equipment

See Preferred Manufacturer List.

J. 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 the Short Circuit and Coordination Studies 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.

K. 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, Materials 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.

L. 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, Materials 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

M.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.

N. 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.

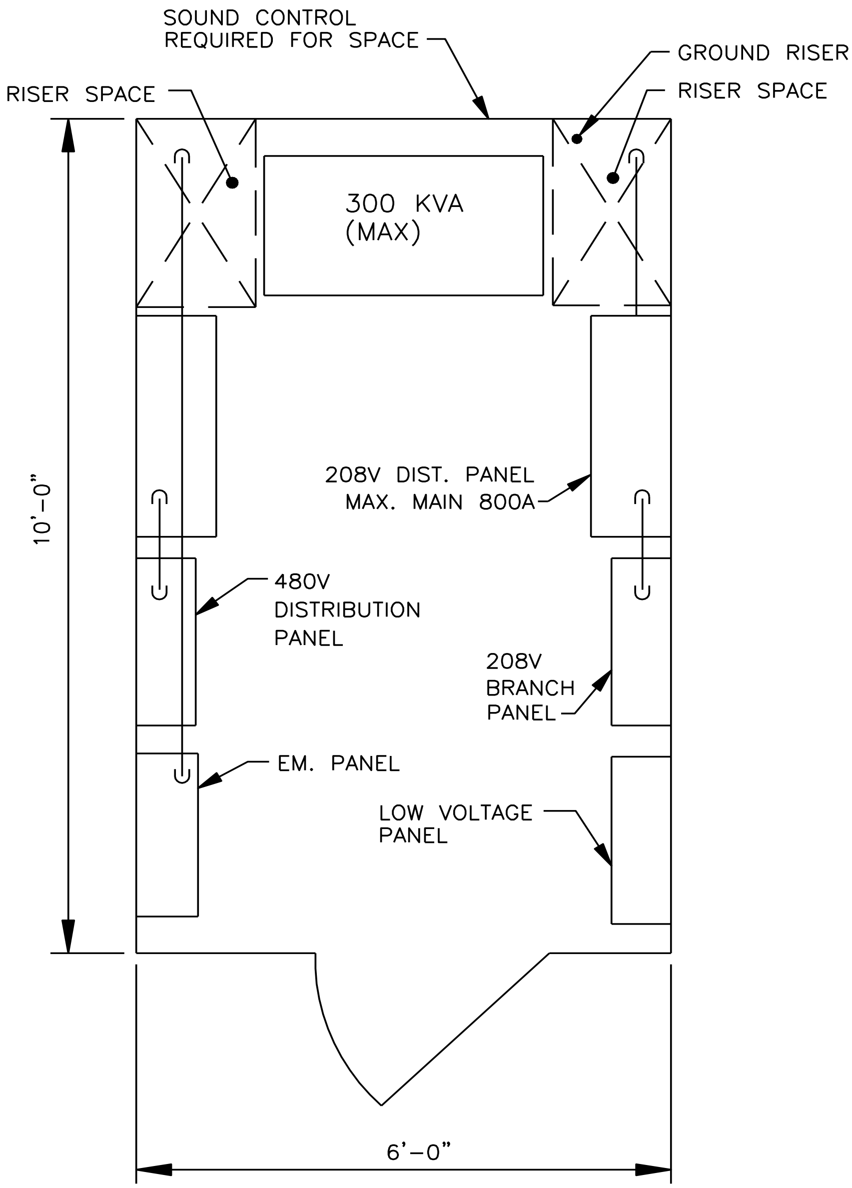
Products, Materials and Equipment

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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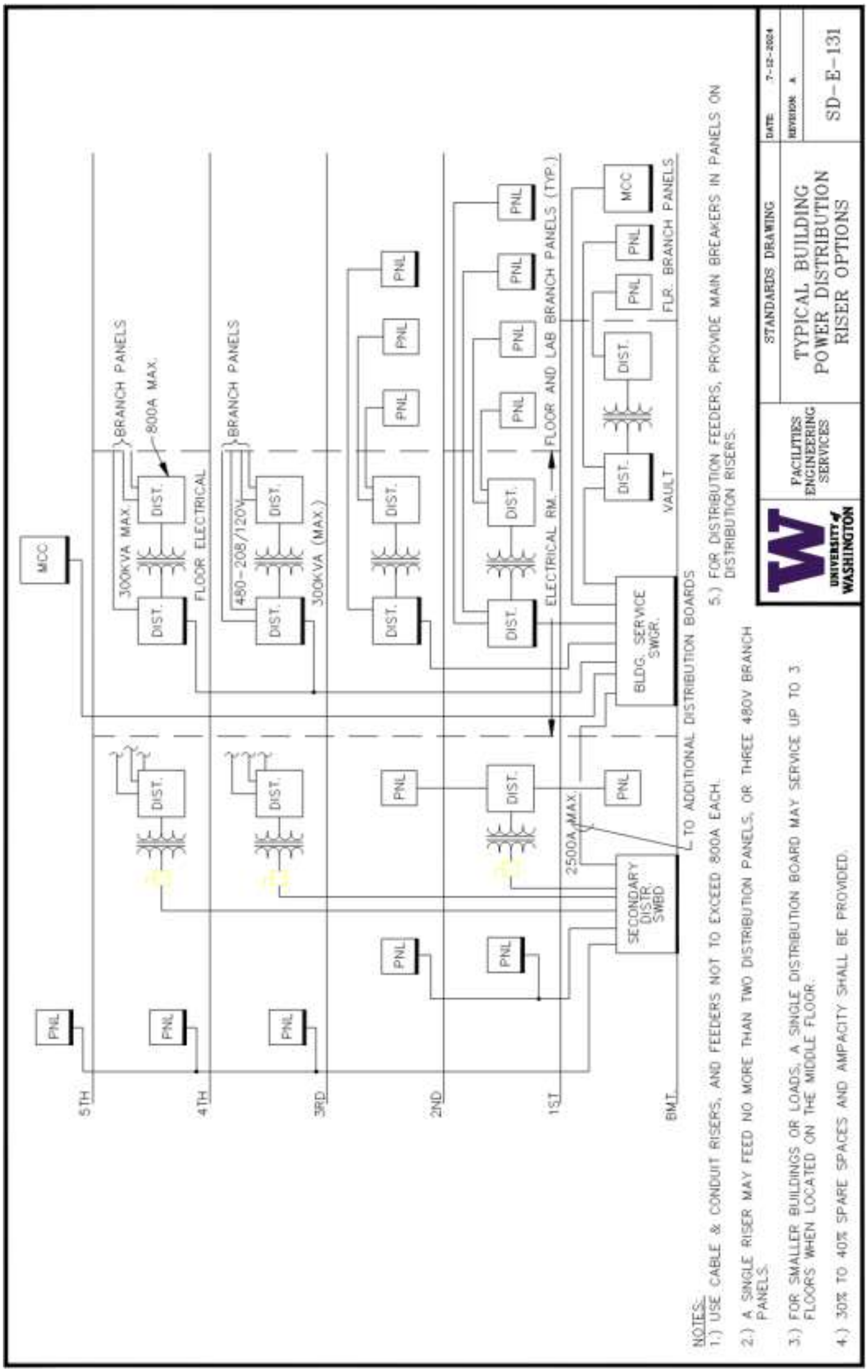
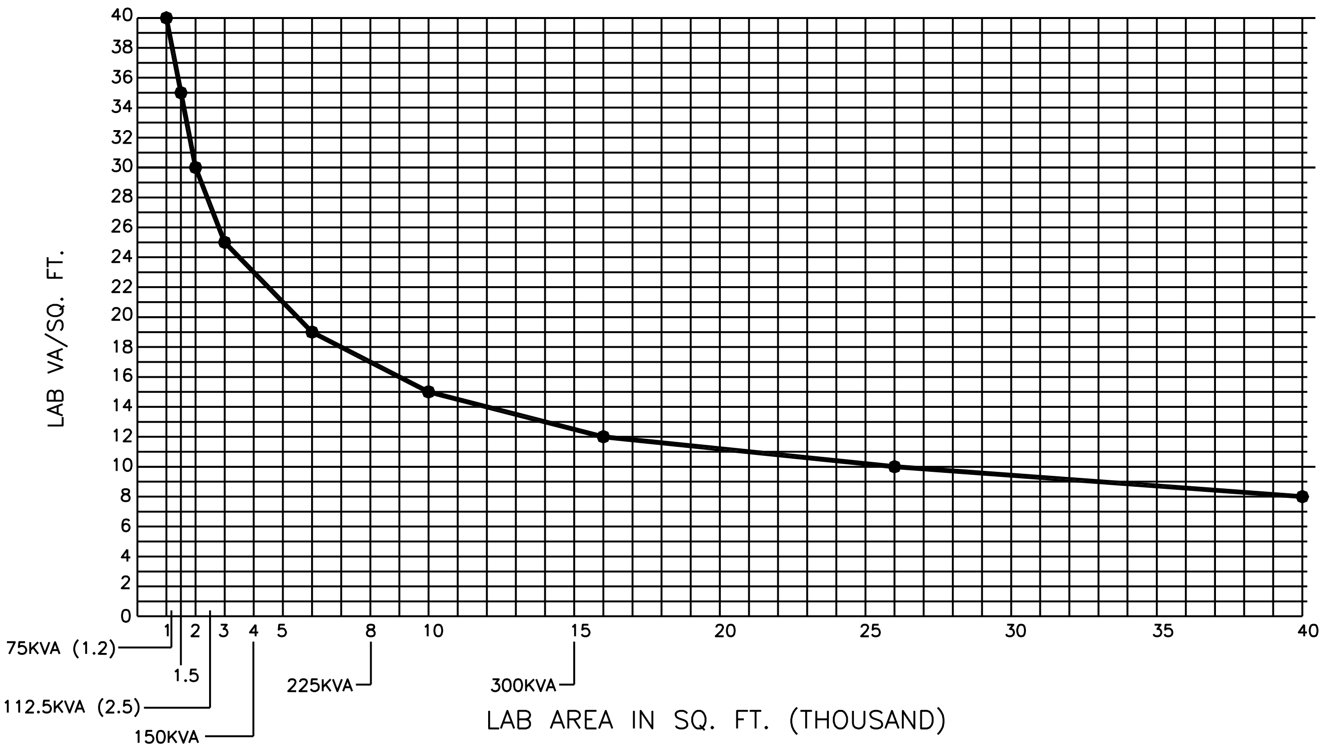


Typical Building Power Distribution Riser

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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O. 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, Materials 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.

P. Panelboards

Basis of Design

This section applies to the design and installation of panelboards.

Design Criteria

1. Panelboards are not allowed for main building service entrance equipment in UW Class N1, N2S, and N2P type services.
2. Panelboards may be used for UW Class N3 services with approval from UW Engineering Services and UW High Voltage Shop. Panelboards for this application shall be front accessible and utilize group mounted thermal-magnetic molded case circuit breakers. Load Centers are not acceptable.
3. Panelboards for multi-floor building risers shall have main circuit breakers.
4. Provide multiple lugs or feed-through type panels when required.
5. Laboratory panels shall have double lugs.
6. 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.
7. Provide isolation panels for Medical Center and other special applications when required.
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 which shall be available on the panelboards after construction is completed.
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.

Q. 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 <u>are</u> 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.

R. 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, Materials 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.

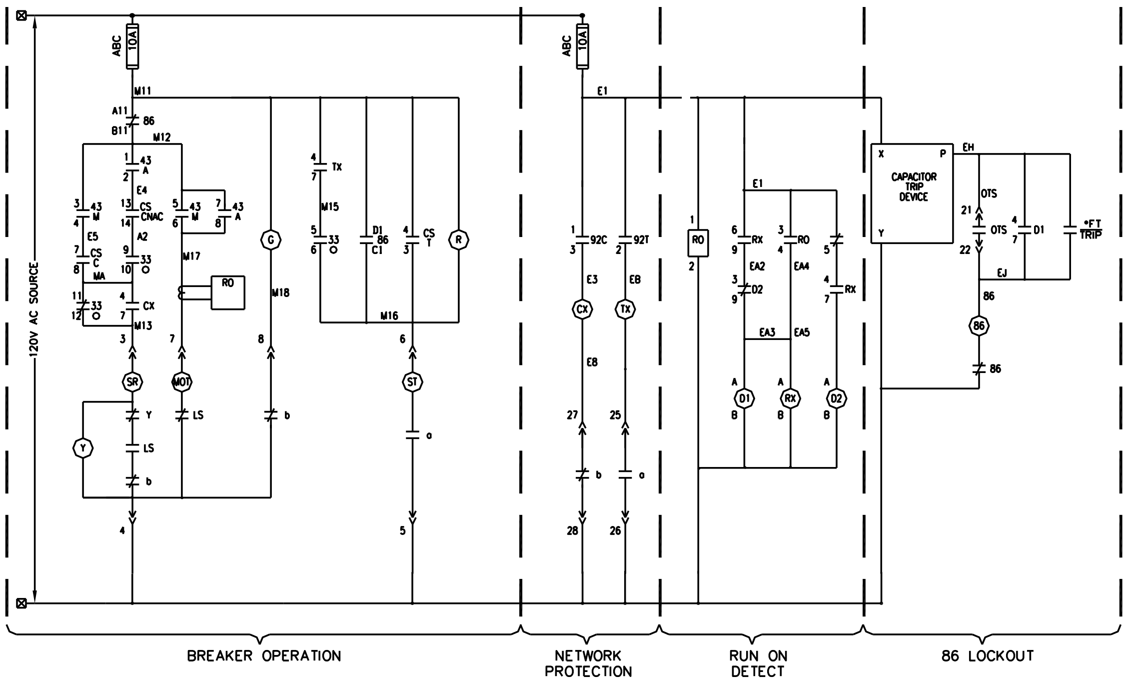
5. For proper operation, network relaying shall work in conjunction with a stored energy device (86 relay). This locks the main breaker out from automatically reclosing after an overcurrent, short circuit or ground fault condition.
6. Current sensing shall be true RMS current.
7. Load demand reclosure 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 below drawing 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.

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.

86 LOCKOUT RELAY.

92 NETWORK PROTECTION RELAY.

• BREAKER IDENTIFICATION SUCH AS M1, F1, T1, ETC.

*/a BREAKER AUXILIARY CONTACT SWITCH, EACH CONTACT CLOSES WHEN CIRCUIT BREAKER IS IN CLOSED POSITION.

*/b BREAKER AUXILIARY CONTACT SWITCH, EACH CONTACT CLOSES WHEN CIRCUIT BREAKER IS IN OPEN POSITION.

*FT/TRIP CURRENT LIMITER (POWER FUSE) CONTACT WHICH CHANGES STATE WHEN ONE OR MORE LIMITERS OPEN.

*/OTS OVERCURRENT TRIP SWITCH, EACH CONTACT CHANGES STATE, WHEN BREAKER IS TRIPPED DUE TO GROUND FAULT, SHORT CIRCUIT, OR OVERLOAD.

CS CONTROL SWITCH, BREAKER CONTROL:
- CS/C-CONTACT CLOSES IN "CLOSE" POSITION.
- CS/T-CONTACT CLOSES IN "TRIP" POSITION.
- CS/NAC-CONTACT CLOSES IN "OFF" POSITION WHEN SWITCH WAS PREVIOUSLY IN "CLOSE" POSITION (NORMAL AFTER CLOSE; PERMISSION TO GO IN AUTO MODE).

CX CLOSE COIL.

D1 RUN ON DETECT TRIP.

D2 RUN ON DETECT TIMER.

LS LIMIT SWITCH CONTACT, OPERATES WHEN SPRING CHARGING MOTOR HAS FULLY CHARGED THE OPEN AND CLOSING SPRINGS IN THE BREAKER.

MOT MOTOR, MECHANICALLY CHARGES THE OPEN AND CLOSING SPRING IN THE BREAKER.

RO RUN ON DETECT RELAY. APPROVED: SSAC PART # ECS41BC

Rx RELAY AUXILIARY CONTACT, RUN ON DETECT.

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.

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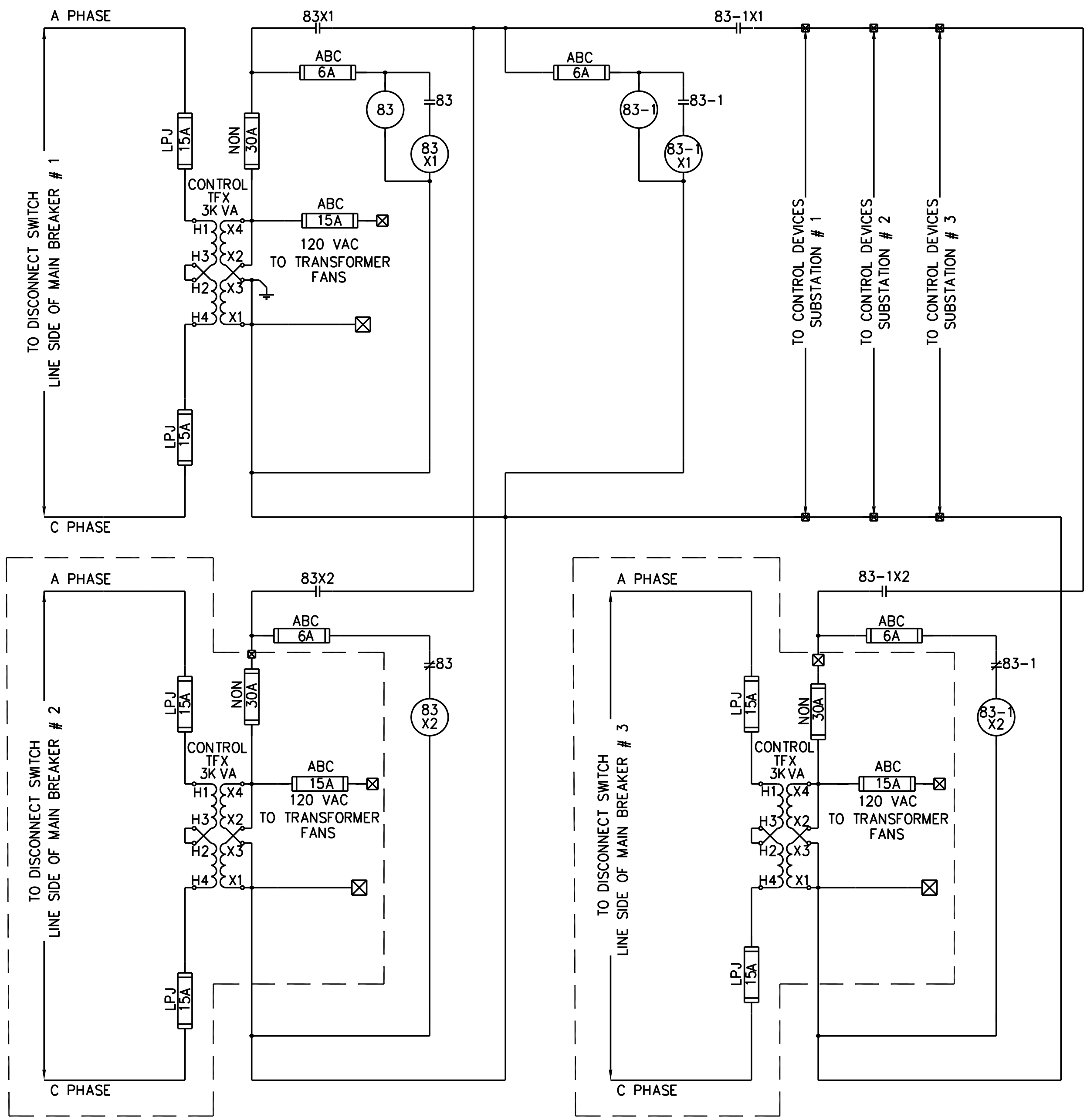

CONTROL POWER TRANSFER SCHEME

SD-E-123

S. 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.

T. 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 ¾” 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.

U. 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.

V. 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. All interior fixtures are required to be LED fixtures. LED luminaires are required to be vetted by the Design Light Consortium (DLC or Energy Star).
    - Fixtures shall be the type that LED lamp array assembly can be replaced without having to replace the entire fixture.
    - For non-dimming, use Type B fixture, single-ended option, direct voltage (277V or 120V)
    - For dimmable, use type C, 0-10V. 120V is preferred.
    - Proprietary drivers are not allowed.
    - Fixtures shall not have plastic components that will melt or deform from heat generated by the fixture.
4. Non-LED, custom, or special order fixtures require UW Engineering Services approval.
5. Use realistic maintenance factors based on products actually used. Provide maintenance access plan as stated in the Design Criteria – Operational Constraints section.
6. Color temperature shall be 3500K, except 4000K in hospital or clinical areas or unless otherwise specified or approved by Engineering Services and Electricians. Other locations:
    - Living areas (dorms)
    - Sales locations (bookstore)
    - Art displays
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. Access to the luminaires must be considered in design. In auditoria and high bay areas, access to fixtures shall use fixture lowering systems. Access requiring scaffolding is prohibited. Refer to Design Criteria section for Job Hazard Analysis requirements in challenging-to-access spaces.

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 up lights or bollards for landscape lighting unless approved by Engineering Services and the UW Landscape Committee.
2. All exterior lighting are required to be LED lamp fixtures.
3. In general, pathway lighting in the UW Seattle campus is required and shall be reviewed and approved by the UW Landscape Committee and Engineering Services. Pathway lighting shall be high cutoff.
4. All street and walkway lighting shall have waterproof overcurrent protection, placed at each pole base and fused based on the connected load.
5. All new or modified street and pathway lighting conductors shall be installed in conduit and an additional 1.25" conduit should be installed for future control conductors. Direct buried cable is not acceptable. Provide a hand hole for each light pole to allow for access to wire terminations and fuses.
6. Luminaires are required to fit, or to be completely adaptable, to existing poles utilized on campus.
7. All fixtures are required to be grouted 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 including accurate topology and labeling of all devices.

Products, Materials 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. Supply luminaire parts with internal disconnects. Sta-Kon disconnects by Thomas & Betts, Cat. No. LD-2, or equal are required.
3. Defective parts replacement, including labor, tools, and access equipment by the manufacturer is required for 10 years after the certificate of occupancy date.
4. Provide 15% spare for each fixture type upon project close-out..

Illuminated Exit Signs

1. Compliance with UL 924 and EPA EnergyStar Specifications at the end of 5 years of continual use.
2. Sign letters shall be green colored.

Installation, Fabrication and Construction

1. Review installation and maintenance approaches with UW Engineering Services.

W. Lighting Control

Basis of Design

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

Design Criteria – Interior Lighting Control

1. Centralized and networked control systems are required.
2. Control systems for new facilities and for major renovation projects shall be “wired” systems and shall be a 2-wire, “non-polarized” system.
3. Wireless systems may be considered for renovation projects when the installation of conduit and wiring is not able to be used. Wireless systems needs approval from UW Facilities.
4. Control systems that utilized batteries for devices and other equipment are not acceptable.
5. Provide data connections as required to the FacNet system. Provide data connections for lighting control server integration including licensing via the secure Facilities Network (FacNet).
6. Automatic controllers and time clocks are required. Maintain time and schedule through a 72-hour power failure. All settings and programming must be maintained during a 72hr power outage event.
7. Provide BacNet connection to the Building Automation System (BAS).
8. Implement zone control for common areas.
9. Lighting control software or application shall be stored on a central server provided by the UW.
10. Provide Graphics User Interface to show light fixture status, controlled outlets and remote programming.
11. Provide service 120v outlet within 5ft of Lighting controller interface.
12. Provide public network port with Facnet port. Next to Lighting controller Brain
13. Label all wiring on both ends with length of wire and downstream device and upstream device designations.

Design Criteria – Exterior Lighting Control

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, that comply with Seattle Campus Lockout-Tagout procedures.
3. Homeruns shall be 1.5” conduit, minimum.

Submittals

1. Provide MAC Addresses for all equipment requiring data connections.
2. Provide all documentation of the final commissioning report, lighting control one-line and wiring diagrams of all lighting control equipment.

3. All verified locations of control components, devices, remote drivers and all other control equipment shall be identified on final delivered one-line diagrams. All equipment should be easy to locate on drawings and diagrams.
4. Provide final software programming backup file. Coordinate delivery of the file with the zone lead electricians to ensure proper storage.
5. All main brain or room controllers are to be installed in electrical rooms and not in ceiling.
6. Provide all proprietary troubleshooting devices for installed lighting control systems used by proprietary lighting technicians, i.e. networking discovery devices, etc.

Products, Materials and Equipment

Interior/Classroom Lighting Control Systems

1. Approved manufacturers for building network lighting control systems: Legrand, Cooper, or approved equal.
2. All models from the above manufacturers shall be a 2-wire non-polarized system.

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.

X. 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.

Y. 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, Materials and Equipment

Develop requirements in the appropriate specification sections.

Installation, Fabrication and Construction

Develop requirements in the appropriate specification sections.

Z. 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.

AA. 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.

BB. Clock and Bell Systems

Basis of Design

All clock and bell systems shall be automatic, self-regulatingsystems that can be synchronized and controlled by the campus master clock and bell system.

Background Information

1. The campus master clock, located in the Plant Operations Building, controls this system. The signals are distributed throughout the campus by a loop running through the utility tunnels. This loop feeds a local clock/bell control panel in each building's main electrical room, which serves as a distribution point for the building. This system is operated and maintained by the Campus Operations Signal System Shop.
2. The Medical Center has separate specialized clock systems, operated and maintained by Medical Center maintenance personnel. Additions shall match existing systems or shall be approved by Medical Center maintenance staff.

Design Criteria

1. Each facility must be given independent considerations in regard to specific clock and bell requirements. The requirements vary depending upon occupancies and relationships to class schedules.
2. Wherever possible, clocks installed in a multi-floor structure should be located in vertical alignment to simplify and minimize raceway systems.
3. Provide clocks in classrooms, corridors, lobbies, auditoriums, large lecture rooms, and multi-occupancy departmental offices.
4. Corridor clocks shall be visible from any point in the corridor.
5. Locate bells adjacent to corridor clocks in buildings with normal class functions and in other locations to be determined by the specific building program.
6. Provide a clock adjacent to the building's local clock/bell control panel to facilitate monitoring and resetting of the local system.
7. For existing buildings, all new or replacement clock systems shall be approved by Engineering Services and Shop 24 (Fire Alarm and Safety Signals).

General Assignment Classrooms Design Criteria

Information maintained by Classroom Services

1. Provide clocks in all general assignment instructional rooms, connected to the campus Master Clock and Bell System.

2. Clocks shall be visible to both the instructor and students. Preferred location is on either sidewall near the front of the room.
3. Bells shall have a manual control switch at 48” AFF (below the clock) to allow instructors to de-activate the bell.

Construction Submittals

1. Provide industry standard submittal requirements for materials and equipment.

Related Sections

1. Facilities Services Design Guide – Electrical - Raceways

Products, Materials and Equipment

1. All components shall be Underwriter Laboratories listed.
2. Clocks
    a) Clocks shall be 120VAC synchronous type, capable of hourly and 12 hour correction, with 12-inch diameter, round face, black trim, semi-flush mounting, and sweep second hand.
    b) Use American Time model U55BAAA532L with semi-flush mounting (2-5/8" deep back box, American Time CFB104) in all finished areas.
    c) Medical Center has specialized clock systems. Match existing systems.
3. Class bells
    a) Class bells shall be 120VAC buzzers. Use Edward Signalling Cat. No. 1065-N5 buzzers mounted in single gang box with stainless blank wall plate cover.
4. Local clock/bell control panel enclosure
    a) Provide a local clock/bell control panel enclosure in the electrical equipment room of each building.
    b) Provide a 16” x 14” x 6.5” NEMA Type 12 Hoffman Cat. No. A-1614CHFTC enclosure with hinged cover.
    c) Provide a panel in the back of the Hoffman enclosure, for mounting relays and other control components.
    d) Provide Corbin, Cat. No. 30 or 102 cabinet lock for enclosure.

Installation, Fabrication and Construction

Division of Work

1. Contractor
    a) Provide and install the local clock/bell control panel enclosure with back panel.

b) Install the clock/bell system cable from the local clock/bell control panel to a junction point in the utility tunnel, specified by the Campus Operations Signal System Shop. Install the cable in a 1-inch conduit or, when available, in communication cable trays, in the tunnel.

c) Provide and install all clocks, bells, and associated equipment including conduit and wiring for the distribution system.

2. Campus Operations Signal Systems Shop

a) Supply, install and terminate the interior components of the local clock/bell control panel.

b) Provide clock/bell system control cable connecting the local control panel to the campus loop, for installation by the contractor.

c) Make final connection to the campus signal loop.

General

1. Power to the local clock/bell control panel shall be dedicated 120-Volt normal power circuits. Provide an accessible junction box outside of the panel room for extending future circuits.
2. Clock/bell riser junction boxes on each floor shall be 6” x 6” x 4”, located in an electrical closet 5' 5" on center above finished floor.
3. Clock/bell system wiring shall be #14 AWG minimum, THHN, solid, copper, conductors installed in separate ¾-inch (minimum), metallic conduit.
4. Clock/bell system wiring shall be color coded as follows:

Function	Color
Clock "Run"	Black
Clock "Reset"	Red
Clock/Bell Common	White
Bell Signal	Blue
Ground Conductor	Green

CC. 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.

DD. Photovoltaic Systems

Basis of Design

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

Design Criteria

1. Systems that utilize a central inverter with "DC to DC" optimizers are preferred versus systems that utilize micro-inverters for each panel.
2. Guaranteed output of solar panels shall be 82.6% after 30 years.
3. Meters for photovoltaic systems shall have 2 data drops: One for FACNET and one for the inverter.

Submittals

1. Shop drawing as-builts are required for final delivery to UW Records
2. Shop drawings shall include an access plan for maintenance and panel replacement.

Products, Materials and Equipment

1. Approved manufacturers are Solar Edge or approved equal.
2. Manufacturers shall have been in the photovoltaic systems business for at least 10 years.
3. Product warranties shall include labor and installation.
   a. Solar panels:
      i. Module product workmanship warranty: 25 years
      ii. Linear power performance guarantee:
         (a) ≥ 97.1% end 1st yr
         (b) ≥ 91.6% end 12th yr
         (c) ≥ 85.1% end 25th yr
         (d) ≥ 82.6% end 30th yr
   b. DC to DC optimizers: 25 years
   c. Central Inverters: 25 Years
4. Zip ties for cabling shall be UV resistant
5. The entire photovoltaic system shall be included in the commissioning process.

Installation, Fabrication and Construction

1. Mounting racks or structural frames for photovoltaic arrays shall be mechanically attached to the roof. See Architectural section, detail SD-A-15, page 13. Note the height requirements of the stand-offs or legs for the rack/frame specified in the detail, but shall be 24" minimum, to facilitate roof inspection, maintenance, and repair. Examples of mechanically attached solar panel arrays:

2. Photovoltaic panel arrays shall be grouped into racks or frames to minimize roof penetrations.
3. Photovoltaic panel arrays shall not be mounted over roof drains.
4. Review installation and maintenance approaches with UW Engineering Services.

EE. Distributed Antenna Systems (DAS) – Puget Sound Emergency Radio Network (PSERN)

Basis of Design

This section applies to the design and installation of distributed antenna systems.

Design Criteria

1. DAS in King County buildings are required by RCW 19.27.031 and WAC 51-54A-003 (which adopts the fire code). The code describes when and how emergency radio systems are required. The Authority Having Jurisdiction (AHJ), usually the Fire Marshal, is responsible for enforcing the code.
2. System shall be connected to UW Campus Energy & Utility Operations FacNet and the building fire alarm system for system monitoring.
3. DAS antennas shall provide pattern coverage that is optimized for indoor requirements at 380-520 MHz (UW Facilities radio), 600-960 MHz (Public Safety), 1395-1435 MHz, and 1690-6000 MHz (Cell phone).
4. Building DAS shall have provisions to be able to connect to a 400 MHz repeater.

Submittals

1. Shop drawing as-builts are required for final delivery to UW Records
2. Shop drawings shall include an access plan for maintenance and panel replacement.
3. Provide drawing detail showing the ability to replace the roof membrane.
4. Provide drawing detail for roof penetrations.

Products, Material and Equipment

1. DAS shall be Laird CMS38606P or approved equal
2. Zip ties for exterior cabling shall be UV resistant

Installation, Fabrication and Construction

1. Review installation and maintenance approaches with UW Engineering Services.
2. The DAS shall be included in the commissioning process.
3. Label both ends of any ethernet cable.
4. Provide test results (similar to the IT infrastructure specifications.)
5. Label all conductors entering the termination box (e.g. fire alarm supervisory.
6. Mount Milbank box with the hinge at the bottom (to be used as a laptop platform. Include chains for a 90 degree platform.

FF. Electrical Identification

For the Electrical Identification Standard Specifications click here.