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## ELECTRICAL

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Basis of Design

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

**Design Criteria**

- 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 Campus Engineering during the programming phase. Such agreed upon exceptions shall be clearly stated in the Technical Program.

- Facility design standards can vary for branch campus and off-site facilities. Review these projects with Campus Engineering to determine modifications to the Facilities Services Design Guide as appropriate. State these approved modifications in the Technical Program.

- 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 guide arbitrarily eliminate an otherwise qualified manufacturer from bidding the project, suggest and review changes to the appropriate sections with Campus Engineering. This may result in a one-time change or in a permanent revision to the design guide.

- Where a detailed analysis of the program reveals an inadequate budget to provide the appropriate system design, notify the Project Manager and Campus Engineering, in writing, of the budget deficiency, the recommended system and its cost, and the alternatives if a budget revision is not provided.

- 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.

- 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.

- Coordinate with Campus Engineering the design of special systems (unique shielded rooms, research and diagnostic equipment, and other equipment and designs not specifically covered by the design guide.)

**Interdiscipline Coordination**

- The Electrical Engineer shall work closely with other design team members to coordinate the design and to insure 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.

- 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.

- Coordinate with Structural Engineer for the design of reinforced concrete housekeeping pad. Secure to structural slab.
Reference Plans and Specifications

- 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 Campus Engineering.

- Several standard type specifications with specific language about the University requirements are included in the design guide. 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. Therefore, the consultant’s standard practices on approved manufacturers, suppliers, systems and equipment may not be appropriate for use on University projects.

Operational Constraints

- 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.

- 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.

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 Campus Engineering 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

- 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.

- 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.

- 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.)
Design Evaluation

The following information is required to evaluate the design:

- **Programming Phase**: Scope of work for electrical systems. Description of hazardous material removal and remediation. Describe exceptions to the Facilities Services Design Guide. Preliminary construction cost and schedule. Identify sustainable goals and targets and proposed strategies to meet those targets.

- **Schematic Design Phase**: Description of electrical design requirements. Construction power point of service. Updated construction cost and schedule. Outline specifications. Identify equipment that is to be re-used or recycled. Provide an update on sustainable goals and targets and proposed strategies to meet those targets.

- **Design Development Phase**: Preliminary electrical design drawings. Identify equipment that produces noise, vibrations and exhaust and the use of products or processes that create hazardous or offensive noise or fumes and the respective mitigating solutions. Identify systems, feeders and services that will require a shutdown and/or a temporary service during the construction period. Identify long equipment delivery time items. One-line diagram of the construction power service. Draft specifications. Provide an update on sustainable goals and targets and proposed strategies to meet those targets.

- **Construction Document Phase**: Complete electrical design drawings. Complete specifications.

Submittals

- Refer to requirements specified in individual Electrical sections.

Related Sections

- All Electrical sections

Products, Materials and Equipment

- Refer to requirements specified in individual Electrical sections.

Installation, Fabrication and Construction

- Refer to requirements specified in individual Electrical sections.

END OF DESIGN GUIDE SECTION
Basis of Design

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

Background Information

- 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.
- 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.
- The University has a campus emergency and standby power system. Refer to the Electrical - Emergency Systems section for detailed information.
- 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.
- 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.
- 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.
- The building transformer secondary main breaker shall be designated as "service disconnect" and "service overcurrent protection".
- 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

- 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.

- For typical Utility Tunnel details, refer to the following Standard Drawings in the "Utility Tunnels and Trenches" Section 2T.
  1) Drawing-Utility Tunnel Section
  2) Drawing-Utility Trench Section
  3) Drawing-Utility Tunnel Manhole Plan
  4) Drawing – Utility Tunnel Electrical Tray Bracket Detail

- Service conductor ductbanks shall be concrete encased and provided with spare cells for future services or cable replacements. Consider ductbank conductor derating per NEC be 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.

- 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.

- Cables are generally subject to ambient temperatures of –20º to +40º C (0 to 105º F).

- 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.

- 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.

- Bends for 5” conduit used for primary medium voltage distribution trunks (500 kcm cable) shall have 5’ 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.

- 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 Campus Engineering.

- Grounding systems shall be provided for all primary distribution ductbanks, utility tunnels, manholes, pulling vaults, transformer pads, switch pads, etc.
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 250 kcm minimum and shall be installed such that they are readily accessible anywhere in the tunnel.

**Design Evaluation**

The following information is required to evaluate the design:

- **Programming:** Identification and location of connection to campus primary distribution system.
- **Schematic Design Phase:** Description of overall primary distribution concept. Identification of work related to tunnels, manholes, ductbanks, and raceway and cable routing. One-line diagram. Outline specifications.
- **Design Development Phase:** Drawings showing distribution routing, raceway and conductor sizing and circuiting. Proposed connection hardware information. Preliminary drawings including utility tunnel/trench sections, manhole plans, tray layout, connection details, grounding details for electrical rooms, tunnel sections, ductbanks, manholes, and vaults. Draft specifications.
- **Construction Document Phase:** Complete drawings showing cable tray, raceway and conductor routing and layout. Final connection hardware information, protection methods, final utility tunnel/trench sections, manhole plans, tray layout, connection details, grounding details for electrical rooms, tunnel sections, ductbanks, manholes, and vaults. Complete specifications.

**Submittals**

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

**Related Sections**

- Facilities Services Design Guide – Electrical - Building Services
- Facilities Services Design Guide – Electrical - Wire, Cable, and Terminations
- Facilities Services Design Guide – Civil - Utility Tunnels and Trenches

**Products, Materials and Equipment**

- Refer to the requirements specified in individual Electrical sections.
- Installation, Fabrication and Construction
- 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.
- 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.

- In special cases, with prior written approval by UW Campus Engineering, 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.

- Do not use cable link boxes for new 13kV splices, connections, and taps. (Cable link boxes are being phased out from the primary distribution system). Utilize cable junction boxes.

- 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 Campus Engineering in designing appropriate worker protection barriers.

- Size junction boxes and electrical vaults for terminations to allow future expansion of the cable system.

- Splices may be placed in cable tray or supported on structure walls.

END OF DESIGN GUIDE SECTION
Basis of Design

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

Background Information – UW Seattle Campus

- The University owns and operates a central plant Emergency and Standby Power System (ESPS). The system consists of a 4.16kV diesel plant and 4.16kV and 2.4kV emergency distribution systems. The generator plant is located in the Power Plant and is 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.

- 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.

- 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.

- The ESPS is configured into three major Plants:
  1) UW Medical Center
  2) General Campus Facilities
  3) Power Plant

- During the initial phases of design, consultants shall confer with Campus Engineering 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.

- 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 DCLU to serve these loads with the following clarifications:
  1) Future high-rise buildings (SBC Section 1807) will also require redundant feeders, or on-site emergency generation equipment.
  2) 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.
  3) Oil switches and other significant sources of fuel shall not be used in the tunnels or electrical rooms that contain portions of the ESPS.
• NEC Article 702 Optional Standby loads will be permitted on the campus emergency power system only on a selective basis and Campus Engineering 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.

• During the initial phases of design, consultants shall confer with Campus Engineering 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 Campus Engineering for requirements and location of on-site generators.

• 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 Campus Engineering for more information.

Design Criteria – UW Seattle Campus

• Most new facilities shall be served from the campus ESPS system or provided with on-site generators for large block load applications.

• 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.

• 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.

• 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.
• Contact Campus Engineering 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).

• The University has adopted a policy to connect all elevators to controlled emergency power.
  1) To prevent the campus ESPS system from being overloaded, elevator systems shall be provided with supervisory controls. Elevators not requiring emergency power by code shall require an override to operate on emergency power.
  2) Refer to the Elevator section.

Design Criteria – UW Tacoma Campus

• The emergency power service concept for UW Tacoma is based on regionally placed generators serving groups of neighboring facilities.

• Dedicated generators are occasionally allowed in lieu of shared emergency power from the regional generator, after careful consideration and with the approval of Campus Engineering. Battery fixtures and UPS systems are not allowed as these systems are costly to operate and maintain.

Design Criteria – UW Other Branch Campuses and Remote Facilities

• Each site has their specific emergency power services. Investigate the existing services and work with Campus Engineering in determining the preferred system.

Design Criteria – All Locations

• 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.

Design Evaluation

The following information is required to evaluate the design:

• Programming: Statement of design intent, including, general description of emergency power provisions, source of emergency power, and distribution. CMCS requirements, if any.

• Schematic Design Phase: Overall design concept and scope for the building emergency power system. NEC branches of emergency power being provided. Emergency load estimate and preliminary emergency riser diagrams. Preliminary generator, ATS, and equipment locations. Cost analysis of using on-site generation. Identify CMCS equipment and I/O points, if required. Outline specifications.

• Design Development Phase: Complete emergency power riser diagrams. Emergency power one-line diagram and schematic diagrams showing the emergency power infrastructure. Completed equipment layouts. Updated emergency load calculations, including generator-sizing calculations. Finalized CMCS I/O points list and associated raceway routings.
- **Construction Document Phase**: Completed information for the installation of the emergency power system. Completed riser and one-line diagrams. Completed schematic diagrams showing generator control, starting procedures, and sequence of operation. Completed design calculations and load summaries. Equipment installation details. Finalized CMCS interconnection diagrams, raceway routings and equipment installation details.

**Submittals**

- Provide standard industry submittal requirements.
- For generator and other equipment, provide shop drawings including the following:
  1) Catalog information
  2) Equipment layout and elevations
  3) Equipment wiring diagrams and connection drawings
  4) Operation and maintenance manuals
  5) Shop drawings

**Related Sections**

- Facilities Services Design Guide – Electrical - Building Services
- Facilities Services Design Guide – Electrical - Primary Systems
- Facilities Services Design Guide – Electrical - Automatic Transfer Switches
- Facilities Services Design Guide - Architectural – Conveying Systems
- Facilities Services Design Guide – Civil - Utility Tunnels and Trenches

**Products, Material and Equipment**

- Generators 175kW and larger shall be Caterpillar.
- Generators smaller than 175kW shall be Caterpillar, Onan or Kohler.
- 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.
- Refer to requirements under Related Sections.

**Installation, Fabrication and Construction**

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

**END OF DESIGN GUIDE SECTION**
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.

- **CLASS N1** - Spot Network - to be used in the University of Washington Medical Center, Health Sciences, and major research and laboratory facilities.
- **CLASS N2** - Primary Radial - to be used in most major education, administration, office and support facilities. This class has two subclasses:
  1) **CLASS N2S** - Includes a secondary tie to a second service bus in the same building (double ended substation) or to a separate building.
  2) **CLASS N2P** - Includes a primary selective switching concept. Only to be used if Class N2S is not possible.
- **CLASS N3** - Secondary Radial - to be used only for small annexes, selected branch campus facilities or other outlying facilities.
- **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.
- **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.
- **CLASS E3** – Academic, administration and support facilities. Designed to meet NEC, Article 700, 701, 702. Does not require bypass/isolation transfer switches.
- **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

- Coordinate with Campus Engineering all connections to existing distribution systems, the service capacity, location and configuration.
- When considering service class, serious consideration needs to be given to the University’s operational constraints. The primary select (UW Class N2P) service requires manual switching to the alternate feeder. Therefore, the primary switches at the vault do not provide quick power restoration from the alternate source. The transfer may take hours, especially if the high voltage staff is not on campus when the outage occurs. The (FOMS) Facilities Operations Maintenance Specialist are on duty 24 hours a day but can only switch up to 480V. Double-ended substations or capabilities to close a tie to another building (UW Class N2S) would allow for the FOMS to provide a quick restoration of power. Spot networks (UW Class N1) provide for the automatic separation of the troubled source, while continuing to serve the load uninterrupted by the alternate source(s). Spot networks are the best choice where reliable, uninterrupted power is required.
• UW Class N1 services shall be designed with maximum reliability and flexibility. UW Class N2 and UW Class N3 services shall be designed with reliability and flexibility commensurate with the function of the facility. For all classes of service, minimize the operation and maintenance costs.

• Maintenance, operation and construction must be able to be performed on a feeder without a power outage to other buildings on the same feeder. This is accomplished by switching the buildings to an alternate feeder. Currently, all facilities on the main campus have this flexibility. This flexibility shall remain a requirement for all new services.

• All services shall have a spare breaker or space at the main electrical service to allow temporary generator hookup to the facility. The breaker or space shall be marked as such.

• All services shall be fully rated. Series rating of equipment for short circuit protection for these classes of service is not acceptable.

Service Transformer Sizing

• 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.

• 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.

• 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.

Design Evaluation

The following information is required to evaluate the design:

• Programming: Statement of design intent on the type of service and description of service equipment and location. Describe system operability and maintainability.

• Schematic Design Phase: Verify service point and connection means. Provide a preliminary one-line diagram and layout of the main electrical room indicating the footprints of all major equipment from each of the approved manufacturers indicating actual dimensions. Outline specifications.

• Design Development Phase: Finalize service connection point. Provide a finalized one-line diagram for the service connection and a final layout of the main electrical room indicating the footprints of all equipment from each of the approved manufacturers indicating actual dimensions. Draft specifications.

• Construction Document Phase: Complete design. Final plan and detail drawings, including the final layout of the main electrical room indicating all equipment from each of the approved manufacturers indicating actual dimensions. Final specifications.
Submittals

- Provide standard industry submittal requirements.

Related Sections

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Switchboard
- Facilities Services Design Guide – Electrical - Primary Systems

Products, Materials and Equipment

- Refer to the requirements specified in individual Electrical sections.

Installation, Fabrication and Construction

- UW Class N1 services (spot networks) shall be in vaults with concrete or solid masonry walls and ceilings per NEC 450-C.
Basis of Design

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

Design Criteria

- 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.
- Use attached drawing, Typical Building Power Distribution Riser, as a guide for building power systems.
- Coordinate with Campus Engineering the distribution concepts, including load calculations, calculated fault duties, protective device coordination methods and grounding practices being utilized on the design.

Architectural Provisions

- 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.
- 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.
- As a general guide, provide one floor electrical distribution room to serve each 15,000 to 20,000 square feet.
- 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.
- 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.
- Closets should be a minimum 2 feet deep by 6 feet wide and equipped with full width double doors opening into a building corridor.
- 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.
• 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.

• 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.

• 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

• 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.

• 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.

• 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. Apply NEC 450-47 for all University electrical vaults, rooms and closets.

Structural Provisions

• 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.

• Provide supports and restraints for Seismic Zone III requirements for all equipment and raceways.

• Coordinate conduit penetrations in slabs, floors, shear walls, structural members, and other structural elements.

Laboratory Buildings

• 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.
• 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.

• 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 hospital and health care facilities per the NEC. Provide hospital grade receptacles in all research laboratories and procedure rooms in the Health Sciences and other physical sciences.

• 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.

• 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
(Information maintained by Classroom Support Services.)

• Classroom electrical services should be protected from surges and spikes. There should be no elevator motors, compressor motors, blower motors, or other types of equipment on the side of the power transformer that feeds the classroom circuits.

• New construction and major renovation should provide for between 40 and 50 percent future expansion in electrical service in each classroom.

• Each classroom should have a minimum of two dedicated 20A circuits not shared by any other room.

• Classrooms seating under 50 persons should have a minimum of FOUR duplex receptacles: one on each side wall and one in each front corner. In addition, each room should have a minimum of two double duplex receptacles: centered on each of the front and rear walls. Locate all receptacles at 18 AFF.

• Auditoria should have a minimum of FOUR duplex receptacles (two on each side wall) and a minimum of THREE double duplex receptacles (spaced evenly along the front wall.) Locate all receptacles at 18 AFF.

• Provide a duplex electrical outlet in the ceiling for ceiling mounted video projector in Level “C” and “E” rooms. Locate service within 4 feet of ceiling mounting bracket as directed by CSS staff. Ceiling outlet should be on circuit not shared with other outlets.

• Auditoria projection rooms should have both 120v and 220v service. 220v service is required for data projectors. The specific type of 220v outlet and its location will be determined with CSS staff during the design/development stage of the project.

• Auditoria should have a breaker panel in the projection booth or control room that provides electrical service for all functions specific to that room. Breaker panels inside instructional rooms are otherwise not acceptable. Panels should be located in either corridors or electrical closets.
• Electrical service is required at podium floor boxes in Level "C" and "E" rooms.
• Floor duplex outlets are required in all classrooms to support overhead projectors and other portable equipment.
• Classrooms may use owner-provided equipment. Provide appropriate wiring and raceways necessary for power and communication systems for owner-provided equipment.
• Refer to Section 18A, Classroom Support Services for additional information.

Design Evaluation

The following information is required to evaluate the design:

• **Programming**: Space planning and provisions for power distribution systems. Statement on power distribution system layout and basis of design.

• **Schematic Design Phase**: Design requirements and location of electrical rooms and closets. Design intent for power distribution system including point of connections and modifications to existing systems. Preliminary power one-line diagram and riser diagram. Electrical load estimate. Outline specification.


• **Construction Document Phase**: Finalize plans for electrical rooms and closets. Final power one-line diagrams and riser diagrams. Final detail drawings of sections, elevations, and schedules for power distribution equipment. Completed load calculations. Completed specifications.

Submittals

• Provide standard industry submittal requirements.
• Refer to requirements specified in related sections.

Related Sections

• Facilities Services Design Guide – Electrical - Building Service
• Facilities Services Design Guide – Electrical - Switchboards
• Facilities Services Design Guide – Electrical - Transformers
• Facilities Services Design Guide – Electrical - Wire, Cable and Terminations
• Facilities Services Design Guide – Electrical - Grounding
• Facilities Services Design Guide – Electrical - Raceways
• Facilities Services Design Guide – Electrical - Electrical Identification
• Facilities Services Design Guide – Electrical - Inspection, Calibration, and Testing
Products, Materials and Equipment

- Refer to requirements specified in related sections

Installation, Fabrication and Construction

- Refer to requirements specified in related sections.

END OF DESIGN GUIDE SECTION
NOTES:
- EXCLUDING LIGHTING AND SPECIAL EQUIPMENT.
- EXCLUDING RELATED STORAGE, OFFICE, OR RECEPTION AREA.
- MINIMUM TRANSFORMER AND FEEDER SIZES NOTED.
  (INCLUDES 40% SPARE CAPACITY)
1. Use cable & conduit risers, and feeders not to exceed 800A each.
2. A single riser may feed no more than two distribution panels, or three 480V branch panels.
3. For smaller buildings or loads, a single distribution board may service up to 3 floors when located on the middle floor.
4. 30% to 40% spare spaces and ampacity shall be provided.
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).
Basis of Design
This section applies to the design and installation of raceway systems.

Design Criteria

- **PVC** (Rigid Non-Metallic Conduit): Direct burial and concrete encased
- **EMT** (Electrical Metallic Tubing): Interior locations where not subject to physical damage; homeruns where additional future circuits are anticipated
- **IMC** (Intermediate Metal Conduit): Not for use in earth or embedded in concrete
- **RGS** (Rigid Metallic Conduit): All raceways in the Power Plant, utility tunnels, and in areas subject to physical damage
- **FMC** (Flexible Metal Conduit): Final connections to devices and equipment; use liquid-tight type for damp locations.
- **IAC** (Interlock Armored Cable): Medium voltage cable rated for use in cable trays. Low voltage service conductors to buildings.
- **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.
- **SMR** (Surface Metal Raceway): Laboratory areas and similar applications
- **Wireways and Cabletrays**: Medium voltage and other special applications and special low voltage applications approved by UW Campus Engineering. Provide separate design information for cable tray used for medium voltage systems and communications systems.
- Other systems may be used with coordination and approval by Campus Engineering.
- Supplement all raceways with equipment grounding conductors.
- 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 are used, most buildings will require conduit for telephone and computer systems (refer to UW Technology Design Guide), one 3-inch for television systems, and one 3-inch for fire alarm, clock, and program systems.
- Refer to section 03-16B for additional criteria when designing raceways for the primary distribution system.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Description of raceway systems required. Outline specifications.
- **Design Development Phase**: Location of exterior duct banks, cable trays, SMR, and other special requirements. Draft specifications for each type of raceway. Cable tray specification for medium voltage systems shall be distinct from communications systems.
- **Construction Document Phase**: Completed site plans showing exterior conduit layout. Drawings showing cable tray and wireway locations. Section cuts for underground conduit
and duct banks. Section cuts above corridors, hallways, and congested areas showing coordination with equipment from other trades. Details for special applications, when required. Completed specifications for each type of raceway. Cable tray specification for medium voltage systems shall be distinct from communications systems.

Submittals

- Provide standard industry submittal requirements.
- Provide support information for cable trays and wireways.

Related Sections

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Identification

Products, Materials and Equipment

- Use industry standards for raceway systems specified and comply with the following additional requirements:
  - PVC, schedule 80 only
  - All 45 degree bends and greater for PVC conduit in MV applications shall be rigid metallic conduit.
  - Rigid metallic conduit shall be shall be hot-dipped galvanized inside and outside.
  - EMT, indenter fittings are not acceptable.
  - Use insulated throat connectors or insulated bushings.
  - 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 Campus Engineering. Connections to SMR shall be through manufactured fittings only.
  - Cable trays for medium voltage applications shall be ventilated, trough, type. Side rails shall be rolled, non-cutting edges.
  - T.V. monitors and cameras use stiff coaxial cable, so outlets shall be 4" x 6 3/4" boxes, 2 1/2 inches deep, with a two gang plaster ring raised 3/4 inch. (Steel City #H2-BD-3/4 1 and #2-GC or equal). Extend a 1 inch conduit from the end of the box to the communications tray.

Installation, Fabrication and Construction

- For raceways that penetrate building exterior, the section of the raceway within the wall shall be sealed inside and around raceway exterior using approved sealant. Where portions of an interior raceway system are exposed to widely different temperatures, as in cold rooms, circulation of air from a warmer to a colder section through raceway shall be prohibited. This sealing is also to be done at penetrations between normal and controlled temperature laboratories.
• 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 Campus Engineering, it may be installed in parking garages, storage facilities, and similar facilities.

• Use of extension rings for junction boxes, splice boxes, and outlet boxes, in new construction, is not allowed.

• Outlets intended for use by portable equipment shall be 18 inches up from the floor. Where conduits feeding these outlets extend up into a false ceiling area and then run 20 feet or more to the cable tray, install a feed-through junction box immediately above the outlet in the false ceiling area.

• RGS and IMC connections shall be watertight.

• Generally, conceal raceway systems. Exposed conduits are permitted only in unfinished areas, SMR systems in laboratory areas, and where approved by the Architect.

• Raceways through roof shall be coordinated with the Architect. Architect to provide roof penetration details.

• Provide expansion fittings for conduits passing through building construction expansion joints.

• Ceiling suspension systems and mechanical ductwork or equipment shall not be used for raceway system support.

Cable Trays

• 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 Campus Engineering. 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.

• Cable tray shall be mounted bottom of tray approximately 6 inches above suspended ceilings. Maintain 10 inches minimum vertical spacing between multiple cable trays.

• Coordinate installation of cable tray with mechanical ductwork, piping, structural members, fireproofing and sprinkler system piping so that tray remains accessible after installation.

• Cable trays shall not penetrate smoke and fire rated walls and floors. Use conduit sleeves for penetrations. Seal all openings in walls and floors around raceways with an approved product to maintain smoke and fire integrity and watertightness.

• Provide an appropriately sized ground cable the length of the tray. Bond to every tray section.

• 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.

END OF DESIGN GUIDE SECTION
Basis of Design

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

Design Criteria

**Medium Voltage**

- Review and modify the attached guide specification as required to meet the project requirements.
- 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.
- Cables are subject to ambient temperatures of –20º to +40º C (0 to 105º F).
- Connection points shall be provided in all electrical vaults and manholes to allow future facilities and other services to be connected to the primary distribution system.
- The following are typical medium voltage connections:

16G – Figure 1
*Manifold Junction Boxes*

16G – Figure 2
*Bolt-T Connectors*
Low Voltage

- All wiring shall be in raceway systems unless otherwise noted.
- Refer to “Electrical – Raceway” section for Interlocked Armored Cable (IAC) applications.
- Refer to “Electrical – Raceway” section for Metal Clad (MC) Cable and Armored Cable (AC) applications.
- Refer to other specification sections for signal and communication type cable and terminations.
- Any low voltage cable in air handling spaces or plenums shall be specifically listed for use in such places (unless in enclosed raceways or conduit).

Design Evaluation

The following information is required to evaluate the design:

- **Programming:** Statement of design intent, including materials and terminating devices.
- **Schematic Design Phase:** Description of overall distribution concept. Outline specifications.
- **Design Development Phase:** Preliminary one-line diagram showing conductor and cable sizing. Preliminary plans showing distribution routing and cable schedules. Indicate the location of connections and types of termination to the primary distribution system. Preliminary detail drawings showing connection hardware information. Draft specifications.
• **Construction Document Phase**: Complete one-line diagram showing conductor and cable sizing. Complete plans showing distribution routing and cable schedules. Final details on location of connections and types of termination to the primary distribution system. Complete detail drawings showing connection hardware information, protection methods and grounding information. Complete specifications.

**Submittals**

- For medium voltage systems, refer to attached guide specification, MV.Wire, Cable and Terminations.
- For low voltage systems, submit standard industry requirements.

**Related Chapters, Sections and References**

- Facilities Services Design Guide – Electrical - Raceways
- Facilities Services Design Guide – Electrical - Identification
- Facilities Services Design Guide – Electrical - Inspection, Calibration and Testing

**Products, Material and Equipment**

**Medium Voltage**

- Refer to attached guide specification MV Wire, Cable, and Terminations.

**Low Voltage**

- Power conductors shall be stranded copper, 98% conductivity. Number 12 AWG is the minimum conductor size. #12 and #10 shall be solid conductor for lighting and receptacle branch circuits, and stranded for motor and equipment circuits and wherever vibration is a consideration.
- Insulation THWN or XHHW (Also THHN when 1/O or smaller)
- Conductor color code per requirements in Electrical – Identification section
- 600 volt control wiring cable shall be in accordance with power conductors above, except #14 AWG shall be permitted and all control wiring shall be stranded.
- "Low voltage" and special cables shall be as specified in subsequent functional sections (e.g. communications, fire alarm, computerized system, television, etc.)
- 600 volt splices shall be:
  1) Solderless type only
  2) Preinsulated "twist-on" type permitted on solid conductor size # 10 and smaller
  3) Hydraulic compression long barrel type with application preformed insulated cover, heat shrinkable tubing or plastic insulated tape for all stranded conductors
  4) For stranded conductors provide terminations designed for use with stranded conductors.

**600V terminations:**
1) 2-hole long barrel compression lugs - 250 kcmil and above
2) Single hole compression lug - Below 250 kcmil
3) Conductors #12 and smaller: Provide eye or forked tongue compression lugs at bolted or screw connections; no lugs required for compression style terminal blocks.
4) Cable ties: Nylon or equivalent, locking type. Use a torque limiting tool for installation of ties.
   • Control cable splices shall be pre-insulated crimp pigtail or butt splice connectors.
   • Control cable terminations shall be locking spade, insulated, compression lugs.

Installation, Fabrication and Construction

Medium Voltage
   • Refer to the attached guide specification MV Wire, Cable and Terminations.
   • 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 Campus Engineering in designing appropriate worker protection barriers.
   • 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.
   • Size cable junction boxes to allow future expansion of the cable system.
   • Do not add link boxes for new medium voltage installations (13kV, 4.16kV, 2.4kV). Utilize cable junction boxes.
   • Use 15kV rated air-insulated sectionalizing switches, cable junction boxes or existing link boxes for 13.8kV systems.

Low Voltage
   • Provide cable ties (limit torque on ties) in panelboards, cabinets, and other unconfined spaces. Group andlace wiring neatly, and do not tie to factory-installed wiring in equipment. Bundle and tag multi-pole circuits in laboratory surface metal raceway.
   • Branch circuits: Homeruns greater than 75 feet to first outlet shall be # 10 minimum.
   • Do not use mechanical means for pulling wires. Use lubricants that do not clog conduits after use. Splices are not allowed in Homeruns.
   • Terminate conductors so that conductor information is easily visible on at least one termination per feeder or within panel or switchboard pulling space.
   • Observe cable bend radius limitations and follow lug manufacturer’s installation procedure.
   • Provide all control wire terminations with approved wire markers which mark the conductor with the terminal number for the wire.
   • Do not score the conductor when stripping insulation, and always pare or pencil when using a blade. Use of a stripping tool is preferable.
• Secure and tighten all terminations in accordance with manufacturer’s recommendations. Remove unterminated wiring unless noted otherwise or specifically approved to remain. Consult with the Engineer for precise instructions.

• Crimp terminations larger than 8awg shall be of the hexacentric type.

END OF DESIGN GUIDE SECTION
UNIVERSITY OF WASHINGTON  Electrical
Facilities Services
Design Guide
Guide Specification
MV Wire, Cable and Terminations

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

ELECTRICAL – MV WIRE, CABLE AND TERMINATIONS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Purpose
   1. This section covers medium voltage cable and terminations for use in the University's primary and secondary power distribution systems.

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

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

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

1.05 COORDINATION

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

1.06 SUBMITTALS

A. General

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

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

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

B. Operations and Maintenance Manuals shall include but not be limited to pull calculations and catalog information indicating complete electrical and mechanical characteristics.

C. Manufacturer’s Certified Test Reports

D. Manufacturer’s AEIC Pre-qualification Data
1.08 MEETINGS

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

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

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

PART 2 – PRODUCTS

2.01 GENERAL

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

2.02 MEDIUM VOLTAGE WIRE AND CABLE

A. The following shall apply to both 5kV and 15kV medium voltage power conductors used as single conductors or assembled into 3/c armored cable:
   1. Single conductors
      a. Conductors: Class B stranded, concentric, soft or annealed copper per Part 2 of ICEA S-68-516
      b. Strand screen: Extruded semi-conducting thermosetting compound applied over the conductor. The material shall be compatible with the conductor metal, shall be uniformly and firmly bonded to the overlying insulation, and be free of stripping from the conductor.
      c. Insulation: High quality heat, moisture, ozone and corona resistant Ethylene Propylene Rubber (EPR) compound
         (1) The insulation shall contrast in color with the strand screen and insulation shield per AEIC CS 6.
         (2) Insulation level shall be 133% (115 mils for 5KV, 220 mils for 15KV).
         (3) The minimum thickness of the insulation at any point shall not be less than 90% of the specified nominal thickness.
         (4) The insulation shall contain no more than 2% polyethylene.
      d. Insulation shield: Extruded semi-conducting thermosetting compound applied directly over the insulation. The material shall be compatible with the insulation and overlying metallic shield. The insulation shield shall be clean and free of stripping from the insulation and comply with Paragraph D.1 of AEIC CS 6.
e. Manufacturing process: The strand screen, insulation, and insulation shield shall be applied with a triple-tandem process providing a virtual corona-free core. The EPR insulation system shall not be exposed to the atmosphere during manufacture.

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

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

2. Armored cable

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

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

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

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

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

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

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

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

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

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

3. Cable rejection

a. Cable shall be subject to inspection by the University at delivery and installation and subject to rejection for shipping and/or installation damage including, but not limited to, jacket penetration, armor denting, or other indications that cable integrity has been compromised.

b. Hi-pot and Megger testing will not be the sole determining factor in the Owner accepting or rejecting damaged cable.
2.03 SPLICES AND TERMINATIONS

A. Medium voltage

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

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

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

➤ IMPORTANT: Specifier to add Exact Requirements for Cable

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

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

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. General installation

1. Identification

   a. Reference section Electrical - Wire, Cable and Terminations

2. Installation

   a. Only personnel qualified and experienced in this type of work shall make connections.

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

      (1) Cables showing damage after installation shall be replaced.

      (2) Rollers and spools shall be used in adequate numbers for pulling in cables.

      (3) The tension limitations, side wall pressure, and minimum bending radius as given by the cable manufacturer shall be observed.

   c. Cable pulling

      (1) In no case will strands be removed to attach pulling eyes.

      (2) Tension is limited to 1000 lbs. using basket grips.

      (3) Lubrication shall be as approved for the insulation and raceway material.

      (4) Prior to pulling, calculations of pulling tension and side wall pressure shall be submitted.
(5) A dynamometer shall be used and tension recorded for all MV pulls.

(6) Use no mechanical means for pulling #8 and smaller AWG conductors.

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

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

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

B. Medium voltage cable terminations

1. Phase mark each conductor, secure conductors adequately and observe cable bend radius limitations. University will identify the West Receiving Station phase rotation convention.

2. System Phase Sequence is C-B-A.

3. MV switch phase terminations shall be A-B-C left to right when facing the front of the switch.

4. Junction box phase terminations are A-B-C left to right.

5. Standard link box phase terminations are A-B-C left to right, top to bottom, front to back. Some existing link box phase terminations are not standard, especially on the 2.4kV normal and emergency power system.

6. The Physical Plant Department High Voltage Shop will identify the phase designation of the existing primary distribution system conductors to which the Contractor is to make a connection.

   a. They will also check the Contractor's work to ensure the accuracy of the connections.

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

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

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

7. Install cable terminations per manufacturer's recommendations.

8. Medium voltage cable splices shall be made only when absolutely necessary. When necessary, splices shall be made only by personnel qualified and experienced in this type of work.

9. Each high voltage splice or connection shall be permanently labeled with the following information:

   a. Contract or project designation

   b. Contractor doing work

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

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

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

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

E. Testing
   1. Provide factory field startup and testing services to assist the ETC (Electrical Testing Contractor) per Section Electrical - Inspection, Calibration and Testing.

END OF GUIDE SPECIFICATION SECTION
Basis of Design

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

Design Criteria

- 13.8kV equipment shall be 15kV class, 4.16kV and 2.4kV equipment shall be 5kV class.
- Equipment must match existing campus switchgear used in similar applications.
- 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.
- 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.
- The enclosures shall have hinged padlockable metal doors on the front and rear of each cubicle (separate doors for upper and lower compartments).
- Design cubicle heaters to operate at half voltage (208V equipment energized at 120V).
- Ground bus attachments shall be via A. B. Chance studs.
- Provide bus to cable termination connections with removable boot insulating covers.
- 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.
- Bus material shall be copper, silver plated at connection points.

Design Evaluation

The following information is required to evaluate the design:

- **Programming Phase**: Describe proposed site, power rating, and connection arrangement (ring bus, preferred/alternate, etc.)
- **Schematic Design Phase**: Describe proposed equipment location, sizes, ratings and space requirements for equipment replacement routing.
- **Design Development Phase**: Describe final equipment sizes and ratings. Provide an outline specification and protection/coordination requirements.
- **Construction Document Phase**: Final plans, including front elevation & section views, fault bracing & seismic anchoring information. Detail drawings showing shipping splits, assembly data, wiring diagrams. Complete coordination study and final specifications.
**Submittals**

- 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.
- Comprehensive instruction manual for installation and operation of each component
- 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)
- Certification of voltage, current, fault, and BIL ratings
- Metering equipment and ratings
- Protective equipment shop drawings
- Manufacturer’s technical bulletins for each protective relay or device
- Component lists
- Nameplate schedule
- Factory and on-site testing procedures
- Factory test records
- Shipping split and bus connection procedures
- Leveling requirements and tolerances

**Related Sections**

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Grounding
- Facilities Services Design Guide – Electrical - Identification
- Facilities Services Design Guide – Electrical - Metering and Monitoring
- Facilities Services Design Guide – Electrical - Testing
- Facilities Services Design Guide – Electrical - Transformers

**Products, Material and Equipment**

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

Installation, Fabrication and Construction

• Incoming line section shall consist of one or more air load interrupter switch(es), quick-make, quick-break, three-pole, gang operated.

• 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

• 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.

• 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.

• Each bay shall be shall be unitized monocoque construction to maximize strength, minimize weight, and inhibit corrosion.

• 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.

• 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.

• Do not use externally accessible hardware for support of high-voltage components or switch-operating mechanisms within the switchgear.

• The integrated switchgear assembly shall have a BIL rating established by test.

Door Construction

• 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.

• Door handles shall be padlockable and, on outdoor gear, shall incorporate a hood to protect the padlock shackle from tampering.

• 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.

• 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.
• 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.

• 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

• 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.

• 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.

• 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.

• 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.

• 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.

• The bus conductor shall not be molded or cemented into the bushing.

• 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.

• Close openings between the bushings and bus conductors with a semiconducting grommet. Fiberglass or porcelain shall not be used for such purpose.

• 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

• Bus supports, bus, and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switchgear.

• Equip bus to where cable will be terminated with grounding provisions. Provide grounding provisions on the ground bus in such bays as well.

• 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 ¼”—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.
- 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.
- In each bay, bolt the ground bus (or connector) to a nickel-plated steel bracket which shall be welded in place.
- 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**

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

**Finish and Features**

- 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.
- 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.
- 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:
  1) 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.
  2) 1000 hours of humidity testing per ASTM D 4585 with no blistering as evaluated per ASTM D 714
  3) 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
  4) Crosshatch adhesion testing per ASTM D 3359 Method B with no loss of finish
  5) 160-inch-pound impact followed by adhesion testing per ASTM D 2794 with no paint chipping or cracking
  6) 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
  7) 3000 cycles of abrasion testing per ASTM 4060 with no penetration to the substrate
- For outdoor enclosures, apply a heavy coat of insulating "no-drip" compound to the inside surface of the roof to prevent condensation.
- 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.
- Lifting eyes shall be removable. Sockets for lifting eyes shall be blind-tapped.
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.

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.

Outdoor switchgear roofs shall be weather-sealed in place with a suitable sealant.

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 be have low-voltage breakers and thermostats.

Delivery, Storage and Handling

- Package and ship breakers and accessories separately from the switchgear structures.
- 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.

END OF DESIGN GUIDE SECTION
Basis of Design
This section covers manufactured structures for electric facilities located outside of buildings, including vaults, handholes and pads.

Design Criteria
• Comply with requirements specified in Seattle Amendment 450-19(a)(1) and WAC 296-46-370 (Boxes and Fittings).
• Refer to section 16B for additional criteria when designing vaults and raceways for the primary distribution system.

Design Evaluation
The following information is required to evaluate the design:
• Schematic Design Phase: Provide a description of proposed equipment locations and types.
• Design Development Phase: Show proposed equipment sizes and conduit entrance locations. Provide draft specifications.
• Construction Document Phase: Provide a description/diagram of final locations and orientation and recommended equipment catalog numbers, including top layouts, grounding details, final conduit entrance details and cable racking details. Provide complete specifications.

Submittals
• Manufacturer’s catalog data

Related Sections
• Facilities Services Design Guide – Electrical - Wire, Cable and Terminations
• Facilities Services Design Guide – Electrical - Grounding
• Facilities Services Design Guide – Electrical - Identification
• Facilities Services Design Guide – Civil – Site Utilities
• Facilities Services Design Guide – Civil – Earthwork
• Facilities Services Design Guide – Civil - Utility Tunnels and Trenches

Products, Material and Equipment
Manufacturers
• Utility Vault Co.
• Renton Concrete Products
• Fog-Tite
• Quazite
Installation, Fabrication and Construction

- Size vault tops to match their vaults.
- Covers shall be factory-marked “ELECTRIC”.
- 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.
- 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.
- 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.
- Coordinate the vault identifier with Campus Engineering. 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.)
- Access hatches and doors for vaults shall be lockable. When equipped with ladders, locks and doors shall be operable from the ladder.
- Ladders for vaults shall be equipped with an extension to allow safe access/egress. Single pole type extensions are unstable and are not acceptable.

END OF DESIGN GUIDE SECTION
Basis of Design

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

Design Criteria

- 13.8kV equipment shall be 15kV class; 2.4kV and 4.16kV equipment shall be 5kV class.
- Space for metering CT’s and PT’s may be required in the switch enclosures.
- 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.
- 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.
- 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”.
- 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. 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.
- 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.
- Where expansion space is available, design switches for future extensions to additional equipment bays.
- Do not use oil and gas insulated switches. (Exception: Pad-mount transformers with integrally equipped switches may be oil filled.)

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Proposed service arrangement, i.e. preferred alternate, double ended, or spot network. Proposed switch location & arrangement.
- **Construction Document Phase**: Switch line-up and enclosure footprint and location, final cable routing plan, cable bending radius details. Cable termination & grounding details, required equipment fault duty. Complete specifications.
Submittals

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

Related Chapters, Sections and References

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Wire, Cable and Terminations
- Facilities Services Design Guide – Electrical - Medium Voltage Switchgear
- Facilities Services Design Guide – Electrical - Metering and Monitoring
- Facilities Services Design Guide – Electrical - Transformers
- Facilities Services Design Guide – Electrical - Grounding
- Facilities Services Design Guide – Electrical - Identification
- Facilities Services Design Guide – Electrical - Inspection, Calibration, Testing

Products, Materials and Equipment

- Approved manufacturers:
  1) S&C Electric, no exceptions.

- 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.

- Interrupter switches intended for manual operation shall be operated by means of an externally operable, nonremovable 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.

- 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.

- 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.
• 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.

• 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.

• Interrupter switches shall have a readily visible open gap when in the open position to allow positive verification of switch position.

• 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.

• 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.

• Provide grounding stirrups in the line and load compartments such that, with the barrier installed, grounding can be achieved without entering an energized compartment.

• All grounding landing pads shall have a “Chance” stud ball.

• 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 Campus Engineering for resolution.

• “Kirk-Key” system is not allowed unless specifically requested by the Campus Engineering and UW High Voltage Shop.

• All switches shall be exterior type, NEMA 3R construction including those installed in utility tunnels and vaults. NEMA 3R switches have larger space requirements and may be mounted on a stand-off frame. Non NEMA 3R switches shall not be used unless approved by Campus Engineering.

• Distribution class surge arresters, rated (6/15)kV shall be provided on each source terminal.

• Approved manufacturer shall be S & C.

• Load side of switch shall be on the bottom.

• If equipped with lightning arresters, they shall be located on the load side of the switch.

• Pad Mount – Manually operated, elbow connected, compartmentalized & fused. May be integral with a transformer.

• Provide two sets of NO and NC contacts for remote monitoring the switch position. Wire the switches out to a terminal strip 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

- 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.
- 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.
- 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.
- 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.

Installation, Fabrication and Construction

- Switches may be installed indoors or outdoors in non-secure areas.
- Provide features and requirements for enclosures similar to medium voltage switchgear requirements.
- For outdoor installations, provide features and requirements for enclosure ventilation, lifting eyes, gasketing and sealing, and space heaters similar to medium voltage switchgear requirements.
- Load connections may be direct (transformer throat) or via cable. Note: Phase rotation is a concern at transformer terminals and may require transition space.
- 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.
Basis of Design

This section applies to the design and installation of transformers.

Design Criteria

- 13.8kV equipment shall be 15kV class. 4.16kV and 2.4kV equipment shall be 5kV class. 15kV class transformers shall have a primary BIL rating of 95kV. 5kV class transformers shall have a primary BIL rating of 45kV. Both classes shall have a secondary BIL rating of 30kV.
- Transformers for 2.4kV use shall be dual voltages rated for use on either 2.4kV or 4.16kV systems. Provide a full range of taps for each voltage. The transformer rating shall not be reduced regardless of the primary voltage used.
- Coordinate with short circuit studies for design fault duties. Determine the required through fault rating of the transformer.
- Specify isolating type with grounded electrostatic shield when serving computer systems.
- Specify High Efficiency K-rated type when serving loads characterized with high harmonic currents.
- Specify ultra-quiet type when installed near offices and classrooms. Noise level shall not exceed 35 db up to 300 KVA and shall be factory certified.

Design Evaluation

The following information is required to evaluate the design:

- Schematic Design Phase: Quantity, size, and rating of transformers based on preliminary load calculations. Outline specifications.
- Design Development Phase: One-line diagram showing quantity and rating of transformers. Preliminary plans showing location of transformers. Transformer type (liquid-filled or dry-type). Draft specifications.

Submittals

- Current manufacturer’s AEIC Pre-qualification data
- Shop drawings including complete description of products to be supplied, product data, dimensions, specifications, connection diagrams, installation instructions, and detailed selection data for vibration isolator supporting equipment, equipment identification mark, the isolator type, and the actual load.
Related Sections

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Power System Studies
- Facilities Services Design Guide – Electrical - Load Interrupter Switches
- Facilities Services Design Guide – Electrical - Wire, Cable and Terminations
- Facilities Services Design Guide – Electrical - Grounding
- Facilities Services Design Guide – Electrical - Wire, Cable and Terminations
- Facilities Services Design Guide – Electrical - Electrical Identification

Products, Material and Equipment

- Approved Manufacturers
  1) ABB
  2) Square D
  3) GE
  4) Siemens
- Unless otherwise specified, transformers shall meet the sound levels of NEMA, ANSI and/or IEEE, whichever is most conservative. Supply certified tests on request of the Owner. Note: This may require that architectural solutions be used.

Dry-Type Transformers

- The transformer shall be of fire-resistant, air insulated, dry type construction, cooled by the circulation of air through the windings.
- Transformers shall be 150 degree C., class H, 220 degree insulation, indoor ventilated dry type, Vacuum Pressure Impregnated.
- The entire core and coil assembly shall be Vacuum Pressure Impregnated (VPI) with a high temperature thermo setting polyester varnish. The total VPI process shall apply a one (1) cycle shield of resin to the coils and bus, core and support structure. The VPI process shall effectively encapsulate the entire core and coil assembly which results in a transformer which is virtually impermeable to moisture, dust, dirt, salt air and other industrial contaminants.
- The electrical insulation system shall utilize Class H material in a fully rated 220 degree C. system. Base transformer design temperature rise on a 30° C average ambient over a 24 hour period with a maximum of 40° C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester on Nomex. All insulating materials must be rated for continuous 220° C duty. The insulation between the high and low voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.
- Transformers shall be of the highest quality, manufactured by firm that has manufactured such apparatus for at least 25 years. Transformer shall have a minimum 98% efficiency.
- Transformers will have high voltage (primary) terminal markings:
  1) “H1” to “A” Phase
  2) “H2” to “C” Phase
  3) “H3” to “B” Phase

- Low voltage switchgear normally connected to building power service transformers will be constructed in accordance with industry standards and will have their buses identified “1”, “2”, “3”, “N”. Transformers will have low voltage (secondary) terminal markings “X1”, “X2”, “X3”, “X0” from left to right or top to bottom when facing the low voltage terminals and the switchgear shall be as follows:
  1) “X1” to “1” (BUS)
  2) “X2” to “2” (BUS)
  3) “X3” to “3” (BUS)

- It is to be noted that transformer connections as indicated above will result in a rotation sequence at the low voltage switchgear of “1”, “2”, “3”.

- All transformers shall be provided with American Standard connection, 30 degree negative angular displacement.

- Transformer impedance should be about 5.75% (7% for three transformer networks). For two transformer networks, special transformer impedances must be determined so that voltage regulation issues are resolved. Confer with Campus Engineering for these applications.

- Enclosure ventilation openings shall be louvered or fine mesh screened. Straight punched holes are not acceptable for safety reasons.

- Transformers shall be provided with the following:
  4) Diagrammatic nameplate listing all detailed information as required by NEMA Standards.
  5) Four 2½ % full capacity taps, two above and two below rated voltage.
  6) Lifting lugs
  7) Base suitable for skidding in all directions. Transformer case shall be supplied in a knockdown design.
  8) Windings shall be copper.
  9) Equipped with a fully insulated secondary neutral bushing (externally groundable) to permit the use of a neutral conductor or current transformer or sensing ground fault currents.
  10) Terminal markings shall be provided on the transformer terminals and shall clearly identify each terminal when doors or covers are opened.
  11) Electrical connections between the transformer and the switchgear shall be provided by the switchgear manufacturer.
  12) Air-filled primary terminal chamber adequately sized for stress cone termination of 3 or 6 single conductors, as indicated.
13) Service transformers serving the "normal" loads shall be provided with automatic temperature-controlled fans. These forced air (FA) units shall contain all necessary components and wiring, including fans, for increasing the KVA ratings by 33% at 150 degrees C. The (FA) package shall include an electronic temperature monitor and fan control unit with the following features: Digital readout, green - power on, yellow - fan on, red - high temperature indicating lights; audible high temperature alarm with alarm silence push button; max. temperature memory with read and reset switch; auto/manual fan control switch; system test switch; temperature sensing in all three low voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from a control power transformer in the secondary switchgear.

14) Emergency Unit Substation transformers shall be pre-wired for future fan cooling, including RTD's or thermocouples imbedded in the windings for temperature control (same as FA package described above but without fans).

15) Provide continuous ¼" x 2" ground bus for connection to adjacent compartment's switchgear.

- The transformer shall be designed to meet the sound level standards for dry-type transformers as defined in NEMA TR1.

- The following factory tests shall be made on all transformers, although not necessarily in the order listed. All tests shall be in accordance with the latest revision of ANSI Test Code C57.12.91 and NEMA TR1, IEEE 262A-1974.
  1) Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this for indoor or outdoor installation
  2) Ratio tests on the rated voltage connection and on all tap connections
  3) Polarity and phase-relation tests on the rated voltage connections
  4) No-load loss at rated voltage on the rated voltage connection
  5) Exciting current at rated voltage on the rated voltage connection
  6) Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project
  7) Temperature test(s) shall be made on one unit only of a project covering one or more units of a given KVA rating. Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one KVA rating, temperature tests as listed above shall be made on the lowest KVA AA rating [and the highest KVA FA rating].
  8) Applied potential test
  9) Induced potential tests

- Steel panel enclosure with louvered openings to guard against insertion of foreign objects
- Ventilated dry type transformers shall comply with ANSI C57.12.51.
Liquid Filled Transformers

- For outdoor use only
- Liquid-filled Pad Mount Transformers shall comply with ANSI C57.12.27
- Dead front design only
- May be integral with primary switching, fusing and separable connection compartment
- Connections shall be via bushing wells for Elastimold or Colt Industries removable studs.
- Removable bushings shall be included.
- Load Break parking stands shall be included.
- Protection shall be via bayonet fuse. No isolation links are allowed.
- Liquid-filled transformers with a capacity of 55-gallons of insulating oil or greater shall have a secondary containment system. This is to prevent oil from discharging to the environment in case of accidental ruptures. The secondary system requirements shall be designed and included in the construction documents.

Vibration Isolation

- MOUNTING TYPE - Unit DNP (Double Neoprene Pad): Neoprene pad isolators shall be formed by two layers of ¼-inch to 5/16-inch thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. These layers shall be permanently adhered together.
- Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.
- A steel top plate equal to the size of the pad shall be provided to transfer the weight of the supported unit to the pads.
- Acceptable manufacturers shall be:
  1) Amber/Booth
  2) Korfund Dynamics
  3) Mason Industries
  4) Peabody Noise Control
  5) Vibration Mountings Control
  6) Kinetics Noise Control

Installation, Fabrication and Construction

- Units shall be anchored to their pads as required to meet seismic zone requirements.
- Initially connect at “normal tap”. After facility is completely energized, measure the primary and secondary voltages at all transformers and service switchboard. Forward a list to Engineer for evaluation. Reconnect and adjust taps as directed. All costs associated with this work are to be included in base bid.
Vibration Isolation

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

END OF DESIGN GUIDE SECTION
Basis of Design

This section applies to the design, installation and integration of metering and monitoring equipment, including: hardware installed in the electrical service and distribution equipment, any required supplemental hardware, equipment and software required for gathering and storing the required data.

Background Information

- The University owns and operates a centralized Energy Monitoring and Management System (EMMS). The system is based on SQL Server 2005. A centralized server is used to import and store all data collected by the various systems installed at the University.

- When meter systems were first installed at the University in the early 1990s, the Cutler-Hammer metering system was used as the basis for the metering system. The majority of the metering equipment currently installed are Cutler-Hammer hardware communicating to a server with the Cutler-Hammer PowerNet software. The system communicates through Ethernet interface products to a PowerNet server located in the Campus Engineering office. Communications is through the campus Ethernet infrastructure (TCP/IP) and Cutler Hammer IMPACC (Integrated Monitoring, Protection and Control Communications) wiring.

- Based on the recent developments in the metering industry the University deems that it is beneficial to allow metering systems from multiple manufacturers to be used for buildings on campus. Each manufacturer’s system shall communicate with a server (located in the Campus Engineering office). Software required for the server shall be provided by the manufacturer. The software shall be compatible with the meters provided and with all meters of the same manufacturer currently installed at University of Washington facilities.

- Should a licensing system be employed, the manufacturer shall upgrade the software and the quantity of licenses to ensure that the entire system is in full compliance with all of the manufacturer’s requirements at the completion of the project. It is intended that each manufacturer’s product line be “stand alone” and the data stored shall be in a manner and form that is fully accessible by Campus Engineering staff. The manufacturer shall also provide any and all required routines/programs required to export all data in a format as specified by the University. The design consultant shall define the University’s requirements in the design documents.

Design Criteria

- Acceptable Manufacturers: Metering systems manufactured by Square-D, General Electric, Siemens or Cutler-Hammer.

- It is intended to provide fully functional meters with power quality analyzers at every Main Circuit Breaker (MCB) for the building.
  1) Acceptable products:
     a) Square-D CM3000 series or ION 7000 Series
     b) Cutler-Hammer/Eaton PX4000 series
     c) General Electric: EPM9000 series
     d) Siemens: 9600 series power quality meter.
  2) Functional requirements shall include but not limited to the following:
     a) Meters shall have “Revenue Grade” accuracy per ANSI/IEEE C12.20-1998
b) Meters must have at least 8 digital auxiliary status/pulse inputs. Digital inputs shall be used for monitoring of the status of MV switches and main breaker(s). They shall also be used for the metering of mechanical utilities and systems.

c) Meters must have an embedded web server with a TCP/IP Ethernet connection.

d) Meters must have local digital displays for all monitored values. The display shall be an integrated component of the meter.

e) Meters must have at least 2MB of onboard non-volatile memory that logs data during communication/server outages.

f) Meters must be able to detect and record voltage sags and swells.

- Sub-metering is intended to provide usage information to enable data monitoring and management related to energy conservation programs. Sub-metering also allows metering capabilities to meet sustainability goals such as those required in Leadership in Energy and Environmental Design (LEED) strategies. Sub-meters shall be provided such that electrical energy data in each building may be monitored and stored for analysis and can be categorized as follows:
  1) Lighting
  2) Convenience outlet power
  3) Mechanical Equipment
  4) Acceptable devices:
     a) Square-D: Multi-Circuit Meter (PMCM)
     b) Cutler-Hammer/Eaton: IQ Multipoint Energy Submeter II
     c) General Electric: EPM4000 series
     d) Siemens: Approved equal to those listed above

- Sub-metering for Emergency and Standby Power is intended to provide usage information to enable management of the capacity and use of the Emergency and Standby Power System (ESPS). Sub-meters shall be installed on the load side of the ATS such that ESPS electrical energy consumed in each building may be monitored and the data stored for analysis:
  1) Meters shall be provided for each Emergency and Standby power ATS.
  2) Meters must display: Voltage, Current, Watts, Vars, PF and energy per phase.
  3) Acceptable products:
     a) Square-D: ION6200 series
     b) Cutler-Hammer/Eaton: IQ200 series
     c) General Electric: EPM2000 series
     d) Siemens: 9200 series power meter

- Any metering system proposed shall be compatible with the existing UW EMMS and be fully TCP/IP compliant. Each building shall be “stand alone” and communicate to the manufacturer’s server solely via TCP/IP compliant products via the UW campus Ethernet backbone.

- Electronic metering shall be provided at all service entrance switchboards and distribution boards, automatic transfer switches, medium voltage circuit breakers and medium voltage motor
starters. Circuit breaker metering for the main, tie, and each feeder breakers is required on UW Class N1, N2P and N2S services.

- Metering/sub-metering is required for tenant spaces and other self-sustaining functions. All equipment serving the metered tenant space shall be fed from the tenant panel(s), it shall be separately metered.

- Coordinate with Campus Engineering the required monitoring and metering points and the connection to the campus EMMS. Also provide for coordination of any server requirements sufficiently in advance of needs to ensure schedule compliance.

- Integration of the building metering into the campus EMMS system shall be achieved through importing data from each manufacturers system into the centralized common SQL database.

- Provide at least two RJ-45, 100-Base-T, data outlet installed in each electrical room as spares, in addition to those required for the metering devices. For locations where connection is made to existing or new C-H Netlinks or equal (gateways), cabling from metering devices to the Netlink/Gateway shall be provided as a part of the project. The design shall include all required routing information including raceway and conductor details.

- Provide switch position monitoring for all medium voltage switches, main and tie-breakers on spot networks and double-ended substations through Form–C contacts. Provide temperature alarm monitoring for all service transformers. The status and temperature alarm inputs shall be connected to the building main electrical meter supplemental I/O inputs.

- Provide one spare of each metering device type installed in the project. Deliver spares to Campus Engineering before project substantial completion.

**Design Evaluation**

The following information is required to evaluate the design:

- **Programming**: Statement of design intent including a general description on how the power distribution system will be monitored and metered.

- **Schematic Design Phase**: Describe the overall design concept and scope for the Energy Monitoring and Management System (EMMS). A list of intended monitoring points and the type of metering device desired. A system description and outline specifications.

- **Design Development Phase**: Provide preliminary diagrams showing the distribution of the communications infrastructure. Provide a finalized list of metering and monitoring points and equipment. Draft specifications. A system diagram based on the specified manufacturer (recognizing that that manufacturer may not be the successful bidder).

- **Construction Document Phase**: Provide detailed diagrams, distribution and connection drawings. Provide detailed elevation drawings showing layout of metering equipment in switchboards and other electrical equipment. Complete specifications. The metering system shall be shown on a separate drawing.

**Submittals**

- Shop drawings including the following:
  1) Catalog information
  2) Equipment layout and elevations
3) Device wiring diagrams and connection drawings
4) Operating manuals and handbooks
5) Required software and instruction manual
6) Quantity and location of each static IP address required by the manufacturers system.

Related Sections

- Facilities Services Design Guide – Electrical - Building Services
- Facilities Services Design Guide – Electrical - Inspection, Calibration and Testing
- Facilities Services Design Guide – Electrical - Medium Voltage Switchgear
- Facilities Services Design Guide – Electrical - Switchboards
- Facilities Services Design Guide – Electrical - Panel boards
- Facilities Services Design Guide – Electrical - Automatic transfer switches

Products, Material and Equipment

- Meters: Refer to Basis of Design.
- Software with appropriate licensing for installation on the ES SQL Server assigned to that manufacturer. (The IP addresses will be obtained and assigned by Campus Engineering).
- All devices installed in a single facility shall be considered a system. All communications within the system, both hardware and wiring are the responsibility of the successful bidder. If devices within the building communicate via TCP/IP a standard C&C data outlet is required.
- Circuit breakers with native power monitoring functionality may be employed as the power monitoring device for sub-metering, provided that the accuracy of the metering portion is better than 5%.
- Current Transformers (CT): Ratio as required; revenue class, 600 volt rating with short-circuiting device, and accuracy meeting the latest NEMA requirements for burden connected to its secondary. Mount and brace all CT’s to withstand mechanical stresses resulting from short circuit currents of 100,000 AIC in the first half cycle of fault.
- Potential Transformers (PT): ANSI accuracy Class 0.3 with terminal covers and mounting base. Protect potential transformers with high-side current limiting fuses, mounted to permit easy removal and replacement without hazard to the operator.
- Neutral bus/conductor current transformers shall be provided on 4-wire systems.
- Provide a 4-pole voltage test block (GE type PK-2 #6422120G3 or equal), a 6-pole current test block (GE type PK-2 # 6422420G4 or equal), a CT shorting block (Marathon 1500 or equal) and a voltage fuse block (Buss #15149-3 or equal) in the installation, mount on panel door.
  - Note the voltage application limitations on the devices listed and utilize PTs, where required, so that the device ratings are not exceeded.
- Communication cable – Shielded twisted pair shall be Belden #9463 or approved equal. Where the manufacturer’s standards require a different type of communications cable comply fully with the manufacturer’s standards.
Installation, Fabrication and Construction

- Control power for metering in networked and double-ended substations shall be derived from the network bus control power such that power will be maintained to the metering system as long as power is available at the network bus.

- Meters in the system that monitor Emergency and/or standby power shall continue to function and record information normally monitored. NOTE: This requires certain portions of the metering system to be served by standby power in order to continue monitoring and communications. All data shall be stored in non-volatile memory.

- Locate Metering Devices such that the readings are displayed at an elevation no higher than 72 inches above the floor (not the housekeeping pad).

- All meters shall be equipped with CT shorting blocks. Test blocks shall be mounted adjacent to the meter. Fuse and CT shorting blocks shall be mounted on the back of the meter panel door.

- Ring-type connectors shall be used for all CT circuits except for devices with captive screw terminals.

- Use SIS type, gray colored wire for all wiring within switchboards and distribution panels.

- Extend technical support for one year from current expiration date.
Basis of Design

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

Design Criteria

- UW Class N1 facilities main switchboards shall be rear accessible. The main, tie and feeder breakers shall be of the drawout airframe type construction.

- 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).

- 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.

- UW Class N3 services building switchboard shall be front accessible and utilize group mounted thermal-magnetic molded case circuit breakers.

- 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.

Design Evaluation

The following information is required to evaluate the design:

- **Programming Phase**: Description of proprietary equipment required. Point of service location and building service category. Preliminary watt/square foot value for loads anticipated.

- **Schematic Design Phase**: Space requirements for working clearances and equipment replacement routing. Description of power distribution and riser diagram layouts for project and layout of the main electrical room indicating the footprints of all major equipment from each of the approved manufacturers indicating actual dimensions. Outline specifications.

- **Design Development Phase**: Preliminary plans including elevations, and a final layout of the main electrical room indicating the footprints of all equipment from each of the approved manufacturers indicating actual dimensions. Preliminary fault, load and seismic calculations. Draft specifications.
• **Construction Document Phase**: Final plans including front view, section views, and attachments for proper seismic and fault bracing and mounting, including the final layout of the main electrical room indicating all equipment from each of the approved manufacturers indicating actual dimensions. Final detail drawings including shipping splits, assembly data and wiring diagrams. Final fault, load and seismic calculations. Final specifications.

**Submittals**
- Catalog cuts including equipment ratings, dimensions, and installation instructions
- Listing by manufacturer standards

**Related Sections**
- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Building Services
- Facilities Services Design Guide – Electrical - Grounding
- Facilities Services Design Guide – Electrical - Identification
- Facilities Services Design Guide – Electrical - Metering and Monitoring
- Facilities Services Design Guide – Electrical – Power System Studies

**Products, Material and Equipment**

**Approved Manufacturers - Switchboards**
1) GE
2) Siemens
3) Cutler Hammer

**Approved Manufacturers – Network Relays**
- Electronic Technology Incorporated (ETI)
- Cutler Hammer MPCV relays
- Other manufacturers shall be pre-approved during the design phase.

**General Technical**
- NEMA PB-2 and UL 891 design equipped with hinged and latched rear access panels and hinged front panel for breaker and metering compartments.
- 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.
- Insulated and isolated silver-plated copper busing
- Provide copper ground through each vertical section.
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.

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.

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 (w/removable cover) or surface mounted raceway.

Main devices requiring energy for operation shall be supplied power from integral bus taps or stored mechanical energy devices.

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.

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.

Flexible braided connectors to transformers

Breakers

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

Provide a breaker programmer Test Kit (one required per project).

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:

1) Cause of trip
2) Instantaneous value of maximum phase and ground currents
3) Approximate level of fault current that initiated an automatic trip
4) Cause of trip LED shall remain illuminated if all power is lost to the breaker.

Main breakers shall have electrically operated closing features for remote and automatic operation.

Tie and feeders breakers shall be drawout breaker similar to main, without electrical operation.
Network Protection Systems

- 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 Campus Engineering.

- 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.

- 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.

- 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.)

  1) 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.

  2) Off position: Network protection is inoperable.

  3) Auto position: The network protection control relays should fully control the auto reclosure of the main breaker.

- 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.

- Current sensing shall be true RMS current.

- 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.

- 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

- Refer to attached drawings Typical Network Control Power Schematic as a guide for designing network protection control power. Network control power shall comply with the requirements below and with the attached drawing and shall be included in the design documents. Deviations from this typical design and construction shall not be allowed unless approved by UW Campus Engineering.

- 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).

- 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 breakers(s).

Installation, Fabrication and Construction

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

END OF DESIGN GUIDE SECTION
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.
• BREAKER AUXILIARY CONTACT Switch EACH CONTACT CLOSES WHEN CIRCUIT BREAKER IS IN CLOSED POSITION.
• BREAKER AUXILIARY CONTACT Switch EACH CONTACT CLOSES WHEN CIRCUIT BREAKER IS IN OPEN POSITION.
• TRIP CURRENT LIMITER (POWER FUSE) CONTACT CHANGES STATE WHEN ONE OR MORE LIMITERS OPEN.
• OVERCURRENT TRIP SWITCH, EACH CONTACT CHANGES STATE WHEN BREAKER IS TRIPED DUE TO GROUND FAULT, SHORT CIRCUIT, OR OVERLOAD.

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 20 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
Basis of Design

This section applies to the design and installation of panelboards.

Design Criteria

- UW Class N3 services building panelboards shall be front accessible and utilize group mounted thermal-magnetic molded case circuit breakers. Load Centers are not acceptable.
- For UW Class N1, N2S, and N2P services building panelboards, provide electronic trip units with long time, short time and ground fault (LSG) protection for molded case circuit breakers. Instantaneous protection shall not be provided since it limits coordination with downstream molded case circuit breakers. Two and preferably three levels of ground fault protection are desired. Selectivity is critical to the University in order to limit the extent of power outages.
- Provide multiple lugs or feed-through type panels when required.
- Laboratory panels shall have double lugs.
- 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.
- Provide isolation panels for Medical Center and other special applications when required.
- Provide “service entrance” listed service entrance applications.
- Series rated panelboards are not acceptable.
- Panelboards shall be 100% neutral rated, or greater when required.
- Panelboards shall be 200% neutral rated when serving non-linear type loads.
- 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.
- 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.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Description of overall design concept for power distribution.
- **Design Development Phase**: Load calculations to determine quantity of panelboards. Preliminary one-line and riser diagrams showing quantity and location of panelboards. Preliminary plans showing panel locations and compliance to clearance requirements. Draft specifications.
- **Construction Document Phase**: Final load calculations to determine quantity of panelboards. Final one-line and riser diagrams showing quantity and location of panelboards. Final plans showing panel locations and compliance to clearance requirements. Completed panel schedules showing circuit numbers and load information. Final specifications.
Submittals

- Shop drawings for review prior to manufacture
- Panel schedules

Related Sections

- Facilities Services Design Guide – Electrical - Identification
- Facilities Services Design Guide – Electrical - Power System Studies
- Facilities Services Design Guide – Electrical - Grounding
- Facilities Services Design Guide – Electrical - Wire, Cable, and Terminations

Products, Materials and Equipment

Approved Manufacturers

- Cutler Hammer
- GE
- Siemens

Cabinets and Fronts

- Dead front type
- 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.
- Provide door-in-door construction with lockable latch fasteners on all doors. All latch components shall be metal. 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.

Circuit Breakers and Fused Switches

- UL interrupting rating labeled
- Coordinate interrupting ratings with the Protective System Device Studies. Minimum ratings shall be as follows:

<table>
<thead>
<tr>
<th>Panelboards</th>
<th>AIC symmetrical</th>
</tr>
</thead>
<tbody>
<tr>
<td>208Y/120V Panelboards</td>
<td>10,000</td>
</tr>
<tr>
<td>480Y/277V Panelboards</td>
<td>14,000</td>
</tr>
<tr>
<td>Fusible Panelboards</td>
<td>100,000</td>
</tr>
</tbody>
</table>

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

Installation, Fabrication and Construction

• Firmly anchor cabinets directly or with concealed bracing to building structure.
• 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.
• Panelboards rated for 400 and 600 amps shall accept 225 amp frame circuit breakers.
• Verify space available with equipment sizes and code required working clearances prior to submitting shop drawings.
• Furnish cabinets prime painted. Do not field paint factory-finished panelboard or equipment covers.
• Locate in dedicated spaces. Coordinate project construction so piping, ducts, etc. are routed around dedicated spaces above and in front of panelboards per code.
• Provide nameplates and directories.

END OF DESIGN GUIDE SECTION
Basis of Design

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

Design Criteria

- Clearly indicate in the drawings and specifications whether the PNP, NPNP and/or BIS style switches and are required. Eliminate sections of the attached guide specifications as required.
  1) Specify Non-Programmed Neutral Position ("NPNP") for NEC 517 and NEC 700 emergency systems.
  2) 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.
  3) 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.
  4) Specify CMCS integration for the University of Washington Medical Center.

- Clearly indicate in the drawings and specifications whether CMCS monitoring and control provisions are required. Eliminate the appropriate sections of the attached guide specification if the CMCS features are not required.
  1) 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.
  2) Other UW Campuses and outlying facilities: CMCS monitoring and control is not required. Consult with UW Campus Engineering to determine what, if any, site specific load management, monitoring and control functionality is required.
  3) 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.

Design Evaluation

The following information is required to evaluate the design:

- **Programming**: Statement of design intent, including identification of transfer switch styles (BIS, PNP or NPNP and CMCS accessories).
- **Schematic Design Phase**: Description of transfer switch requirements. Outline specifications.
• **Construction Document Phase**: Complete automatic transfer switch design, final riser, one-line diagrams and terminal strip wiring and interconnection diagrams for CMCS monitoring and control. Installation details. Control signal connection details, including generator start (if required), fire alarm and elevator control interfaces. Complete specifications.

**Submittals**

• Provide standard industry submittal requirements.

• Refer to attached Automatic Transfer Switch guide specification.

**Related Sections**

• Facilities Services Design Guide – Electrical - Building Systems

• Facilities Services Design Guide – Electrical - Emergency Systems

**Products, Material and Equipment**

• Russelectric, no exception:
  1) UW Class E1 and E2 emergency services
  2) Bypass/Isolation (BIS) style transfer switches

• Russelectric and other manufactures pre-approved by Campus Engineering:
  1) UW Class E3 and E4 emergency services.
  2) Outlying UW Campuses, and other remote facilities.
  3) By-pass/isolation (BIS) not required.
  4) For each project, transfer switches shall be of the same manufacturer.

• Circuit breaker style transfer switches are not acceptable.

**Installation, Fabrication and Construction**

• Refer to attached Automatic Transfer Switch guide specification.

END OF DESIGN GUIDE SECTION
GUIDE SPECIFICATION

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

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

ELECTRICAL – AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Automatic transfer switches (ATS)
   a. Styles and features

   - Consultant shall indicate PNP, NPNP and BIS requirements here. See the guidelines listed above.

1.02 QUALIFICATIONS

A. Pre-approved transfer switches

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

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

B. Pre-approved accessories

   1. Selector switches shall be Electro-Switch, Series 24 or approved equal.

   - Consultant shall eliminate the following requirement when CMCS monitoring is not required.


1.03 RELATED SECTIONS

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

B. Equipment identification
C. Requirements in support of the commissioning process

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

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

1.05 COORDINATION
A. Coordinate with Inspection, Calibration and Testing section
B. Coordinate Operations and Maintenance training times with the University.

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

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS
A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.
B. Operations and Maintenance Manuals shall include but not be limited to wiring diagrams, bus layout drawings, dimensions, front and side views and catalog information indicating complete electrical, mechanical characteristics, startup and testing reports.

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

2.01 AUTOMATIC TRANSFER SWITCH AND BYPASS ISOLATION SWITCH

A. General

1. Each transfer switch shall be enclosed in NEMA-1 general-purpose enclosure with front opening lockable doors. Access into enclosure shall be from the front.

2. All components of the assembly except those identified in these specifications by the manufacturer shall be a regularly manufactured product of the supplier.

3. Nameplates: Identify all equipment, operating handles, and devices on structure (exterior and interior) with engraved plastic laminated nameplates (red background with white lettering). Engraving shall identify equipment, emergency classification and supply sources to match nomenclature identification shown on equipment schematic and wiring diagrams.

4. All relays, timers, control circuitry, and accessories shall be visible and traceable from the front of the enclosure and all control devices, which change position, shall be mounted such that their state can be visually determined without the aid of instruments.

5. Identify all control wire terminations by tubular sleeve-type markers to agree with wire marking identification on manufacturer's equipment drawings.

6. Indicating lamps shall be LED.

B. Automatic transfer switch ratings and performance

1. Transfer to emergency and re-transfer to normal source shall be automatic. Once initiated, NPNP transfer time shall not exceed \( \frac{1}{20} \)th of one second. UL 1008 listed meeting tables 21.1, 23.1, 23.2.

2. The transfer switch shall be capable of transferring successfully in either direction with 70% rated voltage applied to the switch terminals.

3. Each automatic transfer switch shall be rated at 480 volts, 3-phase, 4-pole, for 60 Hertz, normal and emergency sources.

4. All current-carrying parts shall have full 600-volt insulation.

5. The automatic transfer switch and bypass/isolation switch shall have 42,000 Amps minimum RMS short circuit withstand and closing rating when connected to the load side of standard circuit breakers (not current limiting).

C. Construction

1. For NPNP applications, the transfer switch actuator shall be double throw, single electrical operator, momentarily energized; connected to the transfer mechanisms by a simple over-center-type linkage.

2. The transfer switch shall be equipped with a permanently attached safe manual operator design to prevent injury to operating personnel. The manual operator shall provide the same contact-contact transfer speed as the electrical operator to prevent switching the main contacts slowly, and shall allow for manual transfer under full load.
3. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing.

4. Main contacts shall be mechanically locked in position in both the normal and emergency positions.

5. Main contacts: Silver-tungsten alloy. Separate arcing contacts, with magnetic blowouts. Interlocked molded case circuit breakers or contactors are not acceptable.

D. The automatic transfer switch features and accessories:

1. All contacts shall be Form-C dry contacts and wire to a dedicated terminal strip for easy access and connection to remote system.

2. Number the terminals clearly and sequentially with labels indicating which function each terminal block represents.

3. Acceptable nomenclature is “Normal Position (N.O.)” or “Normal Position (Common)” where (N.O.) is the normally open contact and common is common with both (N.O.) and (N.C.).

4. Required remote monitoring contacts and signals
   a. Normal position; four auxiliary contacts closed in normal position (Russelectric #14ax).
   b. Emergency position; four auxiliary contacts closed in emergency position (Russelectric #14bx).
   c. Automatic switch truck position (Russelectric #IS). Normally open dry contact that closes when the ATS is isolated.

5. Adjustable close differential 3-phase sensing relay energized from the normal source, factory set to pick up at 90% and drop out at 80% of rated voltage. Potential transformers shall be multi-tap for either 208V or 480V sensing (Russelectric #VSN).

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

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

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

   a. Manual: Permits pushbutton transfer to normal or emergency
   b. Off: Override to bypass the automatic transfer switch controls so that the transferred switch will remain indefinitely connected to the power source (emergency, normal, or neutral) regardless of the condition of the power sources.
   c. Automatic: All control features ready for automatic sensing and transfer (Exception: Remote control has priority over this switch position) (Russelectric #12a).
   d. Test: Simulates normal power failure with the load test relay (Russelectric #5c).
10. Pushbutton re-transfer to normal, operable only when the 4-position selector switch (Russelectric #6f) is in the manual position.

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

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

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

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

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

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

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

18. Contacts operated from voltage sensing network (VSN) to open on failure and close on restoration of normal source (to CMCS signal) (Russelectric #VSN).

19. Loss of emergency power: Terminals and contacts (3-amp 125 VAC) for remote monitoring of emergency source status (within voltage and frequency limits; not within voltage and frequency limits) (Russelectric #21x).

20. Derangement: Interconnect the following contacts (normally closed) such that any open contact indicates "off normal" condition, including the following:

   (1) Manual/Off/Auto/Test selector switch (acc. 12) is in manual, off, or test position.

   (2) Automatic mechanism of switch is fully isolated (drawn out of the cubicle).

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

E. Sequence of operation

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

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

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

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

Consultant to include the next section for PNP style transfer switches

F. PNP switches

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

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

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

4. PNP transfer switch styles: Provide a maintained two-position selector switch for load shed or block transfer enable/disable. This switch shall be capable of being sealed in either position with a lead or plastic tamper indicating seal. Provide contacts for remote monitoring when this switch is placed in the disable position.

5. PNP applications: Provide adjustable time delays for transferring from the normal to the neutral position and from the neutral to the emergency position. A Load Shed signal shall initiate action that removes the load from the emergency source.

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

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

8. Required PNP monitoring and control equipment, contacts and signals:
   (3) Neutral position; four auxiliary contacts closed in neutral position.
   (4) Load shed keyswitch; closed when keyswitch enabled
   (5) Load Shed keyswitch; enables/disables remote load shed control

Consultant to include the next section for BIS style transfer switches

G. Bypass/Isolation Switch (BIS)

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

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

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

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

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

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

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

8. Accomplish positive sequencing of all contacts, with mechanical linkage which prevents delay in intermediate position, through the manual operators from a dead front location.

9. Electrical testing and maintenance of the automatic transfer switch shall be possible in the bypass position.

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

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

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

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

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

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

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

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

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

➢ Consultant shall eliminate the following requirements when CMCS monitoring is not required.

H. CENTRAL MONITORING AND CONTROL SYSTEM (CMCS) POINTS LIST:

1. The transfer switches shall have the capability of being supervised by the CMCS (Central Monitoring and Control System.)
   - KW and KVAR
   - Loss of normal power
   - Loss of emergency power
   - Derangement:
   - Enclosure intrusion.
   - Auto switch.
   - Load Shed keyswitch.
   - Normal position.
   - Neutral position.
   - Emergency position.
   - Bypassed to emergency position.
   - Bypassed to normal position.
   - Automatic switch truck position.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Installation, mounting and electrical connections

1. In accordance with manufacturer's installation instructions and Seismic Zone 3 requirements

2. Install floor mounted transfer switches on housekeeping pads. Housekeeping pads may present difficulties to remove the automatic switching mechanism for maintenance for large and heavy switches, usually 1000A and larger. For large switches, do not use pads but provide other means to prevent dust and debris from entering switch enclosures.
3. Coordinate remote monitor and control signal connections with the University.

B. Training

1. Provide operation and maintenance training by a factory-trained instructor for two 2-hour sessions of on-site training for a total of 6 maintenance personnel.

2. Include troubleshooting, repair and maintenance manuals for each participant.

C. Testing

1. Provide factory field startup and testing services to assist the ETC (Electrical Testing Contractor) per the Inspections, Calibration and Testing Section.

END OF GUIDE SPECIFICATION SECTION
University of Washington  
Facilities Services  
Design Guide  
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

- Provide MCCs in mechanical rooms and other multi-motor locations. They shall be used in lieu of distribution panels and separate starters in these locations.
- MCCs shall be standard manufacturer design and construction to permit ready installation, removal, or replacement of standard components.
- Provide continuous metering for MCC breakers that will interface with the University’s centralized EMMS system.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Description of overall design concept. Identification of motors to be supplied from the MCCs. Preliminary drawings showing location of equipment.
- **Design Development Phase**: Preliminary drawings showing location and sizes of the MCCs and motors. Preliminary drawings showing feeder routing to the MCCs. Draft specifications.
- **Construction Document Phase**: Final drawings showing location and sizes of the MCCs and motors. Final control wiring diagrams including terminal strip information if required to accomplish control functions. Final MCC elevations. Final layout drawings of the MCCs with the motor and capacitor cubicles shown. Complete specifications for motor control centers and electric motor starters.

Submittals

- Equipment catalog cuts
- Dimensioned installation drawings

Related Sections

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Metering and Monitoring
- Facilities Services Design Guide – Electrical - Raceway
- Facilities Services Design Guide – Electrical - Wire, Cable, and Terminations
- Facilities Services Design Guide – Electrical - Variable Speed Drive Installation
- Facilities Services Design Guide – Mechanical – Motors and VFDs
Products, Materials and Equipment

- **Approved Manufacturers - Switchboards**
  1) Cutler Hammer
  2) GE
  3) Siemens

- Construction shall be NEMA Class I or Class II, Type B, with unit terminal strips only.

- Starter units shall be minimum NEMA Size 1 for uniformity and maximum interchangeability and shall be the circuit breaker combination type.

- 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.

- Combination circuit breaker-type starters are preferred over separate components.

- Full voltage starters shall normally be used. Provide reduced voltage starters in case of motors over 60HP, limited supply power, or unusual load characteristics.

- 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.

- Motor starter circuits shall provide demarcation terminals to allow others to introduce controls both before and after the HOA switch.

- Manual position shall have no automatic controls except overload protection.

- Use automatic position for any automatic control including freezestats, load shed, smoke control, remote manual control, and process control.

- Automatic and manual positions shall have status contacts wired to the starter control terminal strip for smoke control fans and other critical motors.

- 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.

- Pushbuttons, selector switches, pilot lights bases, etc. shall be heavy-duty “oil-tight” devices.

- 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.

- Every control or remote pushbutton shall have an “ON” pilot light.

- Provide red “ON” pilot light and “OFF” pushbutton.

- Provide a green “OFF” pilot light and “ON” push button.

- Pilot lights shall be LED type.

- 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.
• Provide power factor correction capacitors for motors over 15hp. Power factor shall be corrected to 97%.

• 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

• Vertical wiring access shall be accessible from the front without opening individual control units, with hinged cover and captive screws.

• Locate units away from high ambient temperatures and radiant heat sources.

END OF DESIGN GUIDE SECTION
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.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Development Phase**: Description of quantity and location of motors requiring VFDs.
- **Design Development Phase**: Preliminary plans showing locations of the motors and VFDs. Preliminary elevation plans of cubicles of motor control centers feeding the VFDs. Draft specifications in the mechanical section. Harmonic level calculations. Harmonic filtering requirements
- **Construction Document Phase**: Final plans showing locations of the motors and VFDs. Final elevation plans of cubicles of motor control centers feeding the VFDs. Final drawings showing the VFD feeders and indicating conduit and conductor sizes. Final installation drawing details. Specifications in the mechanical section must be complete and coordinated with the electrical specification sections and drawings including the harmonic filters.

Submittals

- Provide standard industry submittal requirements.

Related Sections

- Facilities Services Design Guide – Mechanical – Motors and VFDs

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

- Mount variable speed drives in individual enclosures that are appropriate for the environment where they are located.
- 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.
Basis of Design

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

Design Criteria

- Provide 120V receptacles in janitor closets, toilet rooms, corridors, tunnels and other special purpose spaces for maintenance use.
- 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.
- In general, each circuit’s overcurrent device should be on the same floor as the outlets.
- Provide at least one 120V emergency receptacle in mechanical, electrical and communications rooms, connected to the building standby emergency panel.
- Provide ground fault circuit interrupter (GFCI) receptacles as dictated by good engineering practice. Use master/slave arrangement. Reset must be accessible by users.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Description of overall design concept for wiring device requirements. Special requirements such as hospitals, laboratories, etc. Outline specifications.
- **Design Development Phase**: Preliminary plans showing device locations. Draft specifications.
- **Construction Document Phase**: Completed drawings showing layout and circuiting information. Details for special applications when required. Complete specifications.

Submittals

- Provide standard industry submittal requirements.

Related Sections

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Identification

Products, Materials and Equipment

- Generally use specification-grade self-grounding devices. Use hospital-grade receptacles and attachment plugs for health care facilities and laboratories.
- 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 the Campus Engineering.
• Use neon or low voltage transformer-base pilot lights for long life and ruggedness.

• 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 pigtail. Do not rely on a device’s self-grounding feature.

END OF DESIGN GUIDE SECTION
UNIVERSITY OF WASHINGTON  
Facilities Services  
Design Guide  

Electrical  
Lighting

Basis of Design  

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

Design Criteria

• Select interior lighting to achieve initial system efficiencies greater than 64 lumens per watt. Efficiency can be calculated as follows:
  1) Determine the initial lumen output (Initial lamp lumens X ballast factor X luminaire efficiency) for the luminaires.
  2) Determine the input watts for each luminaire type.
  3) Then calculate the system efficiencies for the different spaces lighted by the various lamp/luminaire types in lumen output per watt.

• Do not rely on prescriptive measures to meet the Seattle Energy Code.

• The lighting design shall maximize the use of recessed and direct/indirect 2' x 4' luminaires using linear fluorescent fixtures T8 or T5. T8 and T5 lamps shall be 20,000+hr rated life for at least 90% of all lighting. In special cases where architectural aesthetics is desired and cannot be achieved by linear fluorescent lighting, compact fluorescent fixtures may be considered. The use of compact fluorescents shall be kept to a minimum and coordinated with UW Campus Engineering. Compact fluorescents, when used, shall have “end-of-life” protection.

• Consider utilizing suspended luminaires as part of an integrated ceiling system design only. If pendant fixtures are used, ensure proper coordination with projector locations and screens in classrooms.

• Use of custom or special order fixtures shall be prohibited, unless approved by UW Campus Engineering in writing.

• Use of incandescent and mercury vapor lamps are prohibited, unless approved by UW Campus Engineering in writing for special cases.

• Do not use fluorescent lamps over 48 inches, T12, U-Bend, or circline lamps, and lamps less than 13 watts (except for auditorium pathway and step lighting). Avoid the use of 1 lamp and 4 lamp T8 ballasts.
  1) Fluorescent lamps greater than 12 watts must be 80+CRI, separable from ballast, and rapid start.
  2) Typical lamps should be 3500K.
  3) In food service areas, any lamp may be 3000K and compact fluorescent lamps may be 2700K.
  4) Use amalgam lamps where compact fluorescent is used in cold or widely variable temperature locations.

• Design for prescribed light levels that use realistic maintenance factors based on products actually used.
  1) For example, the UW-approved F32T8/835 lamps produce an initial 2950 lumens and have a lumen depreciation of 5%, while the more commonly used F32/T735 lamps produce an initial 2850 lumens and have a lumen depreciation factor of 12%. There is an 8% difference in maintained lumens between the two lamp types.
2) T8 luminaires will probably not be cleaned until lamps are replaced at 24,000 to 30,000 hours.

- When making light level calculations, use a ballast factor of .87 for normal output T8 ballasts, 1.18 for high output ballast, and 1.0 for compact fluorescent ballast.

- For radio frequency-sensitive areas such as laboratory and medical center procedure areas, use ballast meeting FCC CFR 47 Part 18 class B requirements and/or provide luminaires with sufficient RFI shielding, including shielded lenses and high integrity ground bonding.

- Ballasts for lamps shall be normal and high output. Do not use low output T8 ballasts. Avoid the use of 1 lamp and 4 lamp T8 ballasts.

- Instant start ballasts are not acceptable unless required by special conditions and approved by UW Campus Engineering.

- Coordinate selection of surface finishes with the architect so as to control brightness ratios, glare, and contrast, while using surface finishes with maximum reflection factors and minimum deterioration.

- Coordinate with the architect so the lighting system can be maintained. Access to the luminaires must be considered in design.

- Access to all lighting equipment must not put personnel at risk and shall not require that personnel bring equipment such as ladders or manlifts unless approved by University plan review.

- Lenses, ballasts, fuses, and all other fixture components shall be available for purchase as individual replacement components for maintenance and repair. Fixtures that require an entire unit to be purchased to replace defective parts are not acceptable.

### 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
- 1 Open parking
- 1 Roadway (use IES recommendation to suit security level)
- 0.5 Walkways (use IES recommendation to suit security level)
Specific Application Requirements

- Due to maintenance difficulties uplights and bollards shall not be used for landscape lighting unless approved by Campus Engineering and the UW Landscape Committee.

- Roadway, pathway and Site lighting: Streets, parking lots, sidewalks, and pathways will generally be illuminated with pole mounted HPS luminaires.
  1) In general, pathway lighting in the UW Seattle campus shall match the performance and appearance of the Archetype series AR/SAR by KIM lighting. Other types of light fixtures to be considered shall be reviewed and approved by the UW Landscape Committee.
  2) Exterior Lighting systems in the UW Seattle campus may have to integrate with the “Cascade” lighting system employed in the campus. Coordinate integration requirements with Campus Engineering.
  3) Lighting equipped with “cut-off” features to prevent horizontal and vertical light pollution. There shall be zero light above 90 degrees horizontal. In campus perimeters prevent light pollution from affecting neighboring communities. Fixture types near bodies of water such as lake Washington, Portage Bay, etc, shall prevent light from reflecting on the water affecting neighboring communities.
  4) Protect all street and walkway luminaires with waterproof in-line fuse holders located in each pole base.
  5) The fuse shall be on the line side of the ballast.
  6) Fixture shall be available in type II, type III, type IV, and type V, square distributions and shall be interchangeable.
  7) Reflectors shall be field rotatable in 90 degree increments, to allow design flexibility in producing very high illumination levels for special applications or for maintaining a consistent fixture orientation throughout the site. Reflector shall be labeled to show the orientation of the light pattern, and can be field adjusted.
  8) Relamping shall be quickly accomplished without tools. The entire electrical module shall snap out without tools, and includes quick-disconnect plugs on all wiring. It shall allow for a spare module to be quickly inserted to eliminate downtime, while the old module is repaired and stored for future use.
  9) The lens frame shall be removable without tools, providing easy lens replacement in the event that breakage occurs. For safety during relamping, the door frame shall be prevented from lifting out of its hinges when hanging in the normal down position.
  10) Fixtures shall have poles that match existing poles used on campus. Get manufacturer and model number from UW Campus Engineering.
  11) Fixtures shall fit or shall be completely adaptable to existing poles utilized on campus.

- Classroom lighting:

  (Information maintained by Classroom Support Services.)
  1) Educational and classroom spaces at the University require use of audio-visual teaching aids.
  2) General classroom lighting should provide 35-42 foot candles at the seat level. Lighting provided for rooms with sloped or tiered floors must take into account the
floor slope to provide consistent foot candles of light across the entire seating area of the classroom.

3) Classroom lighting must be have a full range of brightness, from a comfortable reading level to notetaking in darkened room. Lighting controls within classrooms will be integrated into the UW’s approved equipment and room control system.

4) Provide dimmable low level lighting from 2 to 8 fc. at desk tops, for note taking while viewing projected images. Provide switching for 60% of all luminaires including all perimeter luminaires. Provide dimming for the remaining note-taking luminaires. Dimming shall be accomplished with F32T8/835 lamps and ballasts designed to dim to a 10% ballast factor.

5) In some cases, notetaking light levels may be obtained with selected switching of lamp fixtures rather than true dimming. CSS staff must review and approve the proposed notetaking lighting system for instructional rooms.

6) Notetaking light fixtures shall be located only over the seating area. Note-taking luminaires should provide sharp cutoff optics to minimize illumination of walls and projection screen.

7) Switching to permit operation of the general lighting system by the instructor, speaker and/or projectionist. Low voltage relay control is recommended.

8) An instructor’s spot light should be provided in “C” and “E” level rooms that will allow the instructor to be seen by students during multimedia presentations or other times when the room is darkened. The spot light should be separately switched via a manual switch and the equipment and room control system. Special care must be given to prevent light from spilling onto the projection screen.

9) Provide Independent switching for chalk/marker board and podium lighting as needed.

10) Permanent broadcast lighting shall be provided in Distance Learning/Broadcast classrooms (Level “E”). Required location, controls, type of fixtures, foot candles, and color temperature shall be determined in cooperation with CSS and C&C/UWTV.

11) General lighting should be in or close to the ceiling. Pendant luminaires tend to interfere with the viewing of projection screens and pendant-mounted video monitors.

12) Mount luminaires so lamps are parallel to the front wall.

13) Refer to Section 18A, Classroom Support Services for additional information

14) Classrooms may use Owner-provided lighting systems. Provide wireways and wiring necessary for Owner-provided lighting and control systems.

- **Sports and non-classroom auditoriums:**
  1) Fluorescent lighting may be used for most applications.
  2) Metal halide and other high efficiency lamps may be used for sports and coliseum facilities.
  3) Alternate phasing of HID lamps to reduce flicker effect and to ensure that sufficient instant-start light sources are utilized to avoid total darkness immediately following a momentary power outage.
  4) Fluorescent light fixtures are preferred to low wattage HID lamps.
Library lighting: Maintain a minimum of 50 foot-candles at all study and work surfaces and 15 foot-candles on the vertical surface of a book on the bottom shelf of each stack. Lighting design must be closely related to fixed furniture placement. Study carrels and stacks divide the area into cubicles and aisles. Normal on-center stack spacing is 4’ 6”.

Corridor, entrance lobby, and public area lighting: Break the circuiting into different categories:

1) “Y” circuits: Luminaires located in (non-daylighted) interior areas requiring operation whenever the building is in use

2) “Z” circuits: Luminaires located in (daylighted) open stairways or exterior areas requiring operation during hours of darkness. “Z” circuits should incorporate daylight sensor control with manual override where practical.

3) “Y” and “Z” circuits shall operate by mechanically-held relays or contactors wired for multiple control as follows:

   3.01 Local manual control on each floor (key type or to be located in janitor closets, permitting operation only by authorized personnel)

   3.02 Master manual, keyed control on main floor

   3.03 Master remote control from central supervisor control system

Wet Laboratory Lighting: Provide egress lighting on emergency power near door inside wet laboratories.

Controls

- Multiple switching and split circuiting is preferred to single switching of higher light levels.
- Control all interior lighting with local switching. Do not use standard circuit breakers as light switches.
- Lighting control panels and relays for difficult access spaces such as vivariums, bio-hazard areas, operating rooms, patient rooms, and procedure rooms shall be readily accessible, preferably in hallway outside of space.
- When automatic controls are to be used, occupancy sensors are generally preferred to master lighting control systems to avoid maintaining time schedules.

   1) All lighting controls shall switch loads when output voltage is approximately 0.

   2) Occupancy sensors shall operate in series, with an ON/OFF switch having the look and feel of a typical light switch and mounted in a typical light switch location.

   3) Occupancy sensors shall fail ON.

   4) Occupancy sensors shall have time delay adjustments of 10 to 30 minutes before turning lights OFF. Choose delay settings to minimize ON time while limiting the number of starts to less than 12 per day. Provide a statement of occupancy sensor adjustments in the construction documents. When in doubt, use 10 minutes for meeting spaces such as classrooms and 30 minutes for other applications.

   5) Ensure that the most effective type of sensor is used for different applications. For example, infrared sensors are acceptable for single offices, ultrasonic detectors are more effective for partitioned office spaces, and dual-technology sensors may be necessary for large classrooms. Select the appropriate sensor that will prevent nuisance “on-off” activation of lights.
6) Location of occupancy sensors shall be coordinated with furniture layout, ceiling mounted fixtures and devices, and other features that may impede its operation.

7) Occupancy sensors shall employ wiring methods that will facilitate future relocation of the sensors. For example consider using MC cabling or open-wiring (low voltage) with added lengths that allows relocation anywhere within the space.

- Automatic controllers and time clocks shall maintain time and schedule through a 72-hour power failure.
- Lighting control panels and contactors shall be located away from occupied spaces and be accessible. Electrical spaces and corridor ceiling spaces are acceptable. Latching type relays will be used.
- Systems utilizing a carrier frequency for control shall not be used.
- Locate photocells in protected accessible areas.
- Conduit layout for control wiring shall allow for future changes to the operation of the light fixtures without having to install new conduit from lighting control panels. Conduit shall sized for spare capacity to install additional control wires. A “star” layout shall be used. “Daisy chaining” light fixtures shall be avoided.

Classroom Lighting Control:
(Information maintained by Classroom Support Services.)

1) Manual switching for room lights should be provided at every entrance to the room.

2) Minimum required manual classroom light switching in Level “A” rooms is as follows

<table>
<thead>
<tr>
<th>Preset</th>
<th>Lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All On</td>
</tr>
<tr>
<td>2</td>
<td>½ On (i.e., one half of fixtures or half of all lamps off)</td>
</tr>
</tbody>
</table>

3) Minimum required manual classroom lighting switching in Level “C” and “E” rooms is as follows:

<table>
<thead>
<tr>
<th>Preset</th>
<th>Lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All On</td>
</tr>
<tr>
<td>2</td>
<td>½ On (i.e., one half of fixtures or half of all lamps off)</td>
</tr>
<tr>
<td>3</td>
<td>Front Off; (i.e., fixtures in the front of ceiling projector switched off; fixtures in back of ceiling projector switch on)</td>
</tr>
<tr>
<td>4</td>
<td>Notelights On; dim up/dim down</td>
</tr>
</tbody>
</table>

4) In addition to manual switches, “C” and “E” level rooms should have complete lighting control via the equipment and room control system at the podium, wall, and/or remote handheld device.

5) Equipment and room control system should replicate manual switches and expand on functions to include separate switching of chalk-marker board lights; distance
learning/broadcast lights, podium/speaker spot light. The instructional rooms will have the UW standardized presets in all general use rooms to allow faculty to go from room to room and understand the system.

6) Duplicative lighting controls should be provided in the projection booth and control room that allows remote control of lights in the room.

7) Lighting control systems must be integrated into the building lighting system. Building lighting control systems should be specified to meet Facilities Services Design Guide requirements.

8) Low Voltage Control Cabinet

   A) Provide relay cabinet GE RB-3 (minimum) with RT-1 transformer and RR-8 or RR-9 relays, or as required to support room control system
   B) Provide relay controls for all circuits as listed below, or as specified to support the room control system:

   (a) House lights (e.g., fluorescent, split ballast fixtures for 2 levels of general lighting over the seating area of the auditorium)
   (b) Notetaking lights (e.g., incandescent downlight fixtures over the seating area, with motorized dimmer.
   (c) Front lights (e.g., fluorescent over instructor area)
   (d) Board lights (e.g., fluorescent over chalk/marker boards)
   (e) Projection screen (e.g., 2 relays, 1 for up, 1 for down)
   (f) Audio system (e.g., receptacle in audio cabinet)
   (g) Booth Lights (e.g., fluorescent

9) Provide one SPDT low-voltage momentary switch at each auditorium entrance door. Program entrance door switches to turn on only general fluorescent lights upon entering room but turn off all lighting upon leaving. This can be accomplished economically by using a diode matrix to selectively control standard GE RR-type relays.

10) Projection booth fluorescent light should be controlled by a low-voltage momentary switch at the booth entrance door.

11) Provide control stations at podium and projection booth for full control of all classroom functions (lights, projection screen, audio). If no podium is specified, provide a fixed control station in the instructor area.

12) Refer to Section 18A, Classroom Support Services for additional information.
Design Evaluation

The following information is required to evaluate the design.

- **Schematic Design Phase:** Zones with foot-candle levels are needed for the lighted spaces; provide information on: fixture types to be used, Energy Code requirements, lighting control designs being considered. Describe daylighting plan.

- **Design Development Phase:** Describe the use of daylighting, fixture layout and the switching schemes to be used in the different lighted spaces. Point-to-point light level calculations with the factors used in calculating the levels are needed at this stage to evaluate the efficacy of the design.

- **Construction Design Phase:** At this stage a description of all of the fixtures to be used must be provided with the schedules circuited with the lighting homeruns. Control diagrams are required for the different areas of the lighting design.

Submittals

- Luminaires, lamps and ballasts shall be submitted with all lighting control equipment to be used in the design.

Related Sections

- Facilities Services Design Guide – Electrical - General Requirements

Products, Material and Equipment

- Average luminaire efficiency shall 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%.

- Flat lenses shall be mounted in frames designed for replacement with lenses up to .38 inch thick.
  1) Clear plastic lenses shall be 0.125 inch minimum thickness virgin acrylic.
  2) Use pattern 12 lenses where a diffuse light source is desired.
  3) Pattern 15 lenses are preferred to minimize imaging on video monitors.
  4) Areas intended for exclusive computer use may require Holophane #8248 or high efficiency parabolic louvers.
  5) Sealed luminaires with Corning pattern 79 glass lenses are preferred in sterile areas.

- Fluorescent lamp sockets shall be selected for high frequency ballast use. Typically provide knife-edge lamp sockets. Provide Vossloh rotary lock sockets or similar easy-to-use positive locking sockets for lamps that can fall out of the luminaire if the socket connection fails (such as strip and industrial luminaires).

- Building entrance, landscape and courtyard lighting shall have automatic control. Use enclosed amalgamated compact fluorescent up to 42 watt and 70 watt or higher high
pressure sodium. Luminaires shall be heavy-duty cast non-ferrous metal construction designed to withstand anticipated weather conditions.

- All lighting luminaries including ballasts in fluorescent luminaries shall be equipped with disconnects. Disconnects shall be Sta-Kon disconnects by Thomas & Betts, Cat. No. LD-2, or equal.

Fluorescent T8 Lamp Ballasts

- This specification uses the term "programmed start" to describe ballasts incorporating a starting sequence in which lamps are not started until the $R_a/R_c \geq 4.25$ and $\leq 6.25$.
- Transient Protection shall meet IEEE 587, Category A requirements.
- Socket voltage to luminaire ground or another socket shall not exceed the socket voltage rating under any operating condition.
- Power current flow to lamps shall alternate at greater than 42 kHz.
- Current Crest Factor shall be $>1.35$ and $\leq 1.5$ for rapid start and programmed start ballasts and $<1.7$ for instant start ballasts.
- Ballast shall be UL listed, Class P.
- Ballast shall have a sound rating of A or better.
- Ballasts designated Normal Output shall be programmed-start and have a ballast factor of .85 to .93
- Ballasts designated High Output shall be rapid-start and have a ballast factor of 1.18 to 1.28.
- Ballasts designated Dimming shall be programmed-start and have a ballast factor range of $\leq .05$ to $\geq .90$.
- Ballasts designated Low Temperature shall be used where lamps sometimes start in temperatures below 50º F. Low Temperature ballasts shall start F32T8 lamps at 0º F, shall be normal or high output, shall have less than 20% THD and may be instant start.
- Compact fluorescent lamps shall have rapid-start ballasts.

Fluorescent T4/T5 Lamp Ballasts

- Ballasts shall be electronic rapid-start with a ballast factor of .95 to 1.05, a power factor greater than .95, and less than 15% total harmonic distortion.
- Ballasts shall have protection circuitry which turns off the lamp at the end of lamp life, or if an inappropriate lamp is installed, before damage occurs to lamps, socket, or ballast.

Illuminated Exit Signs

- Illuminated EXIT signs shall use Light Emitting Diodes (LEDs) or cold cathode T-1 lamps as the source of illumination.
  1) The housing and faceplate shall be white in color (other colors must be approved).
  2) Input power shall be less than 5 watts per face and operate on dual voltage 120/277 VAC.
3) EXIT signs shall comply with UL 924 and EPA EnergyStar Specifications at the end of 5 years of continual use.
   • Letters shall be green, not less than 6 inches high, and strokes shall not be less than 0.75 inch wide. Luminance contrast shall be greater than 0.8.
     1) At the end of 5 years of continual use (when measured at 0 degrees and 45 degree viewing angles), average luminance shall be greater than 15 candelas/meter, minimum luminance shall be greater than 8.6 candelas/meter, and maximum-to-minimum luminance ratio shall be less than 20:1.
     2) Letter illumination shall appear even when viewed in a typical installation.
     3) The manufacturer shall replace all defective parts for 5 years from the date of purchase.

Installation, Fabrication and Construction

• Design louvers and lenses to open easily, hang open from the luminaire and be removed from the luminaire, all without the use of tools.

• Support pendant-mounted fluorescent fixtures with one hangar 6 to 18 inches from each end of the luminaire, with a minimum of one hangar, plus an additional one hangar per 8 feet of luminaire.

END OF DESIGN GUIDE SECTION
Basis of Design
This section applies to the design and installation of electrical grounding.

Design Criteria
- Use the UFER grounding philosophy when designing grounding systems.
- Provide all grounding for electrical systems and equipment, including but not limited to:
  1) Service neutral
  2) Raceway systems
  3) Switchboards and panelboards
  4) “Separately derived system” (transformer or emergency power supply)
  5) Electrically operated equipment and devices
- Provide additional grounding requirements for hospital distribution systems when required.
- Provide additional grounding requirements for computer systems and other electrical noise-sensitive equipment when required.
- Provide lightning protection system requirements when required.
- Refer to section 16B for additional criteria when designing grounding for the primary distribution system.

Design Evaluation
The following information is required to evaluate the design:
- Schematic Design Phase: Description of overall design concept and which grounding systems will be included.
- Construction Document Phase: Complete riser diagram for grounding systems. Details of ground busses, lightning terminals, and other grounding equipment when required. Complete specifications.

Submittals
- Provide catalog information for terminations, ground busses, and lightning terminals/plates.

Related Sections
- Facilities Services Design Guide – Electrical - Raceways
- Facilities Services Design Guide – Electrical - Wire, Cable, and Terminations
- Facilities Services Design Guide – Civil - Utility Tunnels and Trenches
Products, Materials and Equipment

- Grounding conductors shall be copper only. Use bare or green insulated in sizes #10 AWG or larger. Use green insulated for size #12 AWG.
- Ground rods shall be ¾” x 10’ 0” copper clad steel.
- 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.
- All ground connections underground or inaccessible for maintenance and repair shall be thermal welding only. Compression connectors are not allowed.

Installation, Fabrication and Construction

- 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.
- Where ground wire is exposed to physical damage, protect with rigid non-ferrous conduit as permitted by applicable code.
- In conduit runs requiring an expansion fitting, install a bonding jumper around the fitting to maintain continuous ground continuity.
- 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.
- Provide a grounding bushing with #10 ground conductor (or larger when required by code) to the grounding bus in the panelboard and switchboards.

END OF DESIGN GUIDE SECTION
Basis of Design

Power Distribution

- Provide a grounding conductor in all raceways for the primary grounding path. Raceways shall serve as the secondary ground path.
- 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.
- Evaluate and specify the appropriate K-ratings for distribution transformers.
- 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.
- 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.
- Provide easy accessible points of attachment to the building grounding system in the building main equipment room.
- Evaluate and provide the following for laboratory bench circuits, computer circuits, sensitive equipment and panelboards as required:
  1) Dedicated circuits
  2) Isolated grounds and isolated ground receptacles
  3) Transient surge suppressors
  4) Power conditioning
  5) Uninterruptible power supplies for critical loads

Surge and Transient Protection

- Provide distribution class surge arrestors on the building main transformer primary terminals to protect from surges and transients on the primary distribution system.
- 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.
- Transient Voltage Surge Suppression – apply as needed. These devices are not a substitute for good wiring practices by the designer.

Lightning Protection

- Lightning protection is to be installed where equipment or liability value is high. Consult with Campus Engineering 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.
- 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.
Design Evaluation

The following information is required to evaluate the design:

- **Programming Phase**: Statement of design intent including the anticipated power quality challenges and the mitigation provisions anticipated.
- **Schematic Design Phase**: Identify areas of the building and equipment where a high degree of power quality is required. Describe the overall design concept for maintaining power quality in these areas and for this equipment. Outline specifications.
- **Design Development Phase**: Provide design details on the power quality provisions. Draft specifications.
- **Construction Document Phase**: Fully implement power quality provisions into the design. Complete specifications.

Submittals

- Develop submittal requirements for the appropriate specification sections.

Related Chapters / Sections

- Facilities Services Design Guide – Electrical - Grounding
- Facilities Services Design Guide – Electrical - Transformers
- Facilities Services Design Guide – Electrical - Panelboards
- Facilities Services Design Guide – Electrical - Wiring Devices

Products, Material and Equipment

- Develop requirements in the appropriate specification sections.

Installation, Fabrication and Construction

- Develop requirements in the appropriate specification sections.

END OF DESIGN GUIDE SECTION
Basis of Design
These standards apply to the design and installation of automatic, self-regulating, clock and bell systems that can be synchronized and controlled by the campus master clock and bell system.

Background Information

- 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.
- 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

- 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.
- Wherever possible, clocks installed in a multi-floor structure should be located in vertical alignment to simplify and minimize raceway systems.
- In general, provide clocks in classrooms, corridors, lobbies, auditoriums, large lecture rooms, and multi-occupancy departmental offices.
- Corridor clocks shall be visible from any point in the corridor.
- Locate bells adjacent to corridor clocks in buildings with normal class functions and in other locations to be determined by the specific building program.
- Provide a clock adjacent to the building’s local clock/bell control panel to facilitate monitoring and resetting of the local system.

General Assignment Classrooms Design Criteria

Information maintained by Classroom Services

- Provide clocks in all general assignment instructional rooms, connected to the campus Master Clock and Bell System.
- Clocks shall be visible to both the instructor and students. Preferred location is on either sidewall near the front of the room.
- Bells shall have a manual control switch at 48” AFF (below the clock) to allow instructors to de-activate the bell.
Design Evaluation

The following information is required to evaluate the design:

- **Programming Phase**: Clock and bell requirements including the areas of the building to be provided with these systems.
- **Schematic Design Phase**: Preliminary riser diagram showing the distribution of the master clock and bell control signals. Outline specifications.
- **Design Development Phase**: Complete riser diagram with location of the building's local clock and bell control panel and the point of connection to the campus loop. Location of the clock and bells within the building. Draft specifications.
- **Construction Document Phase**: Provide a complete specification and detailed riser diagrams, distribution, termination and connection drawings. Finalized location of clocks and bells within the spaces. Complete specifications.

Construction Submittals

- Provide industry standard submittal requirements for materials and equipment.

Related Sections

- Facilities Services Design Guide – Electrical - Raceways

Products, Materials and Equipment

- All components shall be Underwriter Laboratories listed.
- **Clocks**
  1) 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.
  2) Use Simplex clocks (Cat. No. 6310-9231) with semi-flush mounting (3.6 inch deep back box, Simplex Cat. No. 2975-9040) in all finished areas. Surface mounting is to be used in mechanical rooms and as approved by University Campus Engineering.
  3) Medical Center has specialized clock systems. Match existing systems.
- **Class bells**
  1) Class bells shall be 120V AC buzzers. Use Simplex Cat. No. 2902-9501 buzzers mounted in the clock back box according to manufacturer's instructions.
- **Local clock/bell control panel enclosure**
  1) Provide a local clock/bell control panel enclosure in the electrical equipment room of each building.
  2) Provide a 16” x 14” x 6.5” NEMA Type 12 Hoffman Cat. No. A-1614CHFTC enclosure with hinged cover.
3) Provide a panel in the back of the Hoffman enclosure, for mounting relays and other control components.

4) Provide Corbin, Cat. No. 102 cabinet locks.

Installation, Fabrication and Construction

Division of Work

• Contractor
  1) Provide and install the local clock/bell control panel enclosure with back panel.
  2) 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.
  3) Provide and install all clocks, bells, and associated equipment including conduit and wiring for the distribution system.

• Campus Operations Signal Systems Shop
  1) Supply, install and terminate the interior components of the local clock/bell control panel.
  2) Provide clock/bell system control cable connecting the local control panel to the campus loop, for installation by the contractor.
  3) Make final connection to the campus signal loop.

General

• 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.

• 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.

• Clock/bell system wiring shall be #14 AWG minimum, THHN, solid, copper, conductors installed in separate ¾-inch (minimum), metallic conduit.

• Clock/bell system wiring shall be color coded as follows:

<table>
<thead>
<tr>
<th>Function</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock &quot;Run&quot;</td>
<td>Black</td>
</tr>
<tr>
<td>Clock &quot;Reset&quot;</td>
<td>Red</td>
</tr>
<tr>
<td>Clock/Bell Common</td>
<td>White</td>
</tr>
<tr>
<td>Bell Signal</td>
<td>Blue</td>
</tr>
<tr>
<td>Ground Conductor</td>
<td>Green</td>
</tr>
</tbody>
</table>

END OF DESIGN GUIDE SECTION
Basis of Design

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

Design Criteria

- Coordinate design requirements for the following systems:
  1) Public address systems
  2) AMX: Room Control System
  3) Audio Systems
  4) Intercom systems
  5) Security systems
  6) Nurse call systems
  7) CCTV/Television systems
  8) Alarms and remote monitoring
  9) Electrically operated windows and shades
  10) Automated whiteboards and projection screens

- All systems shall be designed to utilize modern equipment and shall be arranged to provide flexibility, ease of expansion and accessibility.

- Provide low voltage cable tray distribution system for use by all low voltage systems. Coordinate with Electrical-Raceway section.

- Identify spaces for terminal equipment required for miscellaneous signal systems. Coordinate with the mechanical designer to provide adequate cooling in the spaces.

- When required, a raceway system shall be provided for connection to campus distribution systems in the utility tunnels for miscellaneous signal systems.

- Assisted listening systems should be incorporated into classrooms and auditoria based on federal ADA legislation.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Summarize overall design concept for each system, especially an understanding of the service size for proper space requirements. Indicate what systems will be included. Describe points of service. Outline specifications.

- **Design Development Phase**: Provide preliminary riser diagrams, size calculations and space allocations for each system. Show preliminary details of wiring interconnection of systems supplied by different divisions. Show equipment layout of main service equipment. Draft specifications.
• **Construction Document Phase**: Provide final riser diagrams. Final plans showing equipment and device location. Equipment schedules. Final interconnection system diagrams. Final specifications.

**Submittals**

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

**Related Sections**

- Facilities Services Design Guide – Electrical - General Requirements
- Facilities Services Design Guide – Electrical - Raceway

**Products, Material and Equipment**

- Intercom – Manufacturers: 3M, Pamex, Valcom.
- Nurse call systems shall match existing and/or approved by UW Medical Center operations and maintenance staff. Control cabinets shall have muffin fans for sufficient heat circulation and removal and 30 second Agastat timer to delay incoming power restoration.
- Paging - TOA, Dukane: Equipment selected must be of heavy-duty type of a proven, reliable manufacture. Units shall be connected with plug-in components and plug-connected assemblies. General building paging shall be a 70-volt system with speakers that have output taps from 0.5 to 2 watts.
- Room control systems shall be AMX system, which is currently used in instructional rooms.
- The audio mixer(s) or mixer/amplifiers should provide a minimum of 6 input channels, with plug-in input modules. Preferred standard equipment is TOA 900 Series. Classroom services staff must approve all equipment.

**Installation, Fabrication and Construction**

- Arrange pre-construction meeting prior to rough-in installation.
- Require photos of equipment rough in where complication and density are high.
- Locate a duplex receptacle adjacent to outlets for TV monitors and cameras, to be controlled from a central position by low voltage relays.
- In auditoriums or lecture rooms where there are projection rooms, run outlets to the projection room rather than a central building cable tray. The projection booth shall have a conduit connection to the building system.
- Electrically operated projection screens require both power and control from the projection booth and other central positions, and shall be low voltage controlled.
• Rooms with AMX systems should include infrastructure to support both a hardwired touch panel (in the podium or a wall-mounted application) as well as wireless remote control units. Wireless units require a storage location in the room that can be secured and that provide power to recharge the remote’s batteries.

• In-room PA systems should include capabilities to support:
  1) A hard-wired microphone located at the podium
  2) A wireless microphone
  3) Auxiliary input(s) and record output(s) to enable easy audio recording of the speaker.

• In addition to standard program audio equipment (e.g. audiocassettes, audio-CDs, videotapes, etc.) the program audio system should support computer-generated audio (e.g. multi-media presentations) from the podium.

• Special audio needs required for distance learning/broadcast should be incorporated into the room design with special consideration given to the need for student microphones and audio requirements at the distant site.

• Rooms with program audio systems and rooms with PA systems should be controlled by the AMX touch panel.

• Direct two-way communication between the instructor and the operator in a projection booth and/or control room should be provided. An 8-inch full-range speaker should be provided inside the projection booth and/or control room that is tied into the classroom/auditorium sound system for monitoring the audio system from the projection booth.

• Full control over the room’s audio sound system should be available in the projection booth/control room. Controls should include 16mm film audio input, auxiliary input with volume control, and record output.

• The auditorium speaker system should be designed to provide uniform coverage of +/- 2DB, 80-8000 HZ minimum over the entire seating area of the auditorium for both sound reinforcement and sound reproduction.

END OF DESIGN GUIDE SECTION
Basis of Design

This section applies to the requirements for identification of electrical raceway, conductors, and equipment.

Design Criteria

Review and modify attached guide specification Electrical - Identification as required to meet the project requirements.

Design Evaluation

The following information is required to evaluate the design:

Schematic Design Phase: Outline specifications.
Design Development Phase: Draft specifications.
Construction Document Phase: Complete specifications.

Submittals

Refer to Electrical - Identification guide specification.

Related Sections

Facilities Services Design Guide – Electrical - Raceway
Facilities Services Design Guide – Electrical - Wire, Cable, and Terminations
Facilities Services Design Guide – Electrical - Switchboards
Facilities Services Design Guide – Electrical - Panelboards
Facilities Services Design Guide – Civil - Utility Tunnels and Trenches

Installation, Fabrication and Construction

Refer to Electrical - Identification guide specification.

END OF DESIGN GUIDE SECTION
GUIDE SPECIFICATION

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

ELECTRICAL – ELECTRICAL IDENTIFICATION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Purpose

The purpose of this section is to provide electrical identification for electrical equipment, raceway, and conductors.

B. General

1. Provide labels, nameplates, panel directories and color-coding as specified herein and according to attached electrical identification drawings.

1.02 RELATED SECTIONS

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

1.03 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI A13.1 Operational and Warning signs

1.04 SUBMITTALS

A. General

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

2. Prior to making nameplates, submit a complete schedule indicating nameplate size, lettering size, color, and actual nameplate information.

1.05 MEETINGS

A. Within one month after “Notice to Proceed”, schedule a meeting with UW representatives to review electrical identification requirements.
PART 2 - PRODUCTS

2.01 EQUIPMENT NAMEPLATES AND DEVICE LABELS

A. Materials
   1. Provide nameplates constructed of 1/16-inch thick plastic laminated material. Engrave through colored surface material to contrasting colored sub-layer.
   2. Use receptacle labels by electronic labeler Brother P-Touch, model PT-20/25, Dymo-Tape or approved equal.

B. Provide nameplates for the following:
   1. Equipment identification labels for all electrical equipment including, but not limited to, switchgear, switchboards, panels, transfer switches, disconnect switches, transformers, capacitors, fixed equipment, motor starters, MCC's, motors, etc.
   2. Subclassification labels for all emergency power system equipment as listed for equipment identification labels, and all junction and pull boxes.
   3. Fire Alarm equipment per the Fire Alarm specification
   4. Cubicle/space labels for all MCCs, substations, and distribution switchboards
   5. Identify fuse type and size on the cover of fusible equipment.
   6. Special equipment outlet labels (¼-inch letters)
   7. GFCI receptacles: "Series GFCI Protected"
   8. Time delays: Provide ¼-inch lettering at the control location to identify a motor having a time delay relay - "Time Delay Start to Limit System Inrush."
   9. Cover plate receptacle labels shall indicate panel and circuit identification for all receptacles.
   10. In addition to receptacle labels, provide labels for fixed equipment at a visible location mounted on or near the equipment. Examples of fixed equipment are refrigerators, water fountains, hoods, ranges, dishwashers, etc. Coordinate location of labels with the University.
   11. Pathway Lighting. Indicate power source. (Bldg name, panel and circuit number).

2.02 RACEWAY LABELS

A. Identify medium/high voltage conduits within buildings and electrical rooms by painting on its full length the following:
   1. Stenciling in 2-inch black letters: Stencil to be placed once in each room and at a minimum of every 50 feet. Place where convenient for tracing. Exception: Stencil not required if conduit does not exit room.
   2. Stencil to include source equipment name, voltage, load equipment name (i.e. PCU-BB01-E01/4160V/TR-SW01-E01)
3. Paint medium voltage conduits: Emergency system conduit, (4.16 kV and 2.4 kV) - red; normal system conduit, (13.8 kV) - yellow. For other medium or high voltage systems, contact UW Campus Engineering for color scheme.

B. Feeder and branch circuit conduits

1. No labeling required for raceways with readily identifiable terminations within the same room

2. In accessible ceiling spaces and exposed in unfinished areas, label conduit with panel and circuit numbers of conductors routed through the conduit. Label conduit at all wall penetrations and connections to all panels, junction boxes, and equipment served.

3. Use a black indelible marker and hand print label in a clear workmanlike manner, or use stencil and black paint to provide a clearly legible label.

C. Empty conduits

1. Provide labels with description of purpose, and location of opposite end, on each end of conduits provided for future.

2. Equipment or those abandoned as a result of this contract: Cardboard or plastic handwritten tags are permissible. Note accurately on as-built drawings.

2.03 BRANCH CIRCUIT PANELBOARD DIRECTORIES

A. Provide neatly typed schedule under plastic jacket or protective cover for protection from damage or dirt.

1. Number each single pole space: Odd-numbered circuits on left side or top, even on right side or bottom.

2. Securely mount on inside face of panelboard door.

3. When no cover, provide individual nameplates for each overcurrent and other device.

4. Define briefly, but accurately, nature of connected load (i.e., Lighting Office, Receptacles, Mechanical/Electrical Room, etc.) as approved.

5. Provide room locations for all loads and indicate panel name on schedule.

6. Multipole circuits to utilize first pole space number as its circuit number

B. Confirm room numbers with U.W. Construction Coordinator prior to noting on schedules.

C. Spare circuit breakers and space positions shall be noted in pencil.

D. Panel schedules and as-built circuit numbers shall agree.

2.04 WIRE AND CABLE LABELING

A. Control wiring

1. All control-wire terminations are to be identified by tubular sleeve heat shrink-type markers to agree with wire marking identification on manufacturer’s equipment drawings.
B. Power conductor wire, cable and buses

1. Buses, feeders, branch circuit conductors and medium voltage cables shall be properly phased and identified throughout. Individual conductors shall be color coded as noted below:

<table>
<thead>
<tr>
<th>Conductor</th>
<th>120/208V (note 1)</th>
<th>277/480V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>Phase B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>Phase C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>Gray</td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Isolated Ground</td>
<td>Green/Yellow</td>
<td>Green/Yellow</td>
</tr>
</tbody>
</table>

Note 1 – This color code also applies to medium voltage phasing at cable terminations. Identify color-coded conductors with appropriately colored plastic vinyl tape (3M #190-A).

a. Buses and connections shall be identified left to right, top to bottom, or front to rear; shall read A-B-C; and shall be color-coded per the table above.

b. Feeders for all new construction shall have color-coded phase identification at all junction boxes and wherever feasible, and shall have solid color-coded insulation for phase designation. Where the proper color wire insulation cannot be obtained, black insulation shall be used and the conductors shall be coded with plastic vinyl tape, 3M #190-A, 3/4-inch or equal.

c. Identify color-coded conductors with appropriately colored plastic vinyl tape (3M #190-A) in the panel when branch circuits are reconnected for balancing panel load.

C. "Low voltage" cable and special systems

1. See individual functional specification sections.

2.05 COLOR SCHEME FOR LABELS (See attached standard drawings for examples):

<table>
<thead>
<tr>
<th>System</th>
<th>Label Color</th>
<th>Lettering Color</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4kV &amp; 4.16kV Emergency</td>
<td>Red</td>
<td>White</td>
<td>&quot;EM - LS&quot;</td>
</tr>
<tr>
<td>13.8kV Normal</td>
<td>Yellow</td>
<td>Black</td>
<td>&quot;EM - CR&quot;</td>
</tr>
<tr>
<td>2.4kV Normal</td>
<td>Orange</td>
<td>White</td>
<td>&quot;EM - LRS&quot;</td>
</tr>
<tr>
<td>Normal Power and Control</td>
<td>White</td>
<td>Black</td>
<td>&quot;EM - OS&quot;</td>
</tr>
<tr>
<td>Emergency Power and Control:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency - Life Safety</td>
<td>Red</td>
<td>White</td>
<td>&quot;EM - LS&quot;</td>
</tr>
<tr>
<td>Emergency – Critical</td>
<td>Red</td>
<td>White</td>
<td>&quot;EM - CR&quot;</td>
</tr>
<tr>
<td>Emergency - Legally Required</td>
<td>Red</td>
<td>White</td>
<td>&quot;EM - LRS&quot;</td>
</tr>
<tr>
<td>Standby</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency - Optional Standby</td>
<td>Red</td>
<td>White</td>
<td>&quot;EM – OS&quot;</td>
</tr>
<tr>
<td>Fire Alarm</td>
<td>Red</td>
<td>White</td>
<td>&quot;FA&quot;</td>
</tr>
<tr>
<td>Halon</td>
<td>Dk. Blue</td>
<td>White</td>
<td>&quot;FP&quot;</td>
</tr>
<tr>
<td>Security</td>
<td>Green</td>
<td>Black</td>
<td>&quot;SEC&quot;</td>
</tr>
<tr>
<td>Intercom, Public Address, Nurse Call</td>
<td>Orange</td>
<td>Black</td>
<td>&quot;IC&quot;, &quot;PA&quot;, or &quot;NC&quot; (as app.)</td>
</tr>
<tr>
<td>Clock</td>
<td>Lt. Blue</td>
<td>Black</td>
<td>(Symbol for Clock)</td>
</tr>
<tr>
<td>TV</td>
<td>Yellow</td>
<td>Black</td>
<td>&quot;TV&quot;</td>
</tr>
<tr>
<td>Communication Data</td>
<td>Black</td>
<td>White</td>
<td>&quot;C/D&quot;</td>
</tr>
</tbody>
</table>
PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Attachment

1. Securely attach engraved labels and nameplates with rivets or screws.

2. Clean surfaces thoroughly before attaching all labels. Use solvent on device plates before attaching electronic or Dymo-tape labels. (Without proper cleaning, electronic or Dymo-tape labels will soon curl off.)

3. Drill hole in nameplate and attach to motor flexible conduit with plastic tie-wrap.

B. No temporary markings permitted to remain on equipment. Remove all temporary markings where possible. Where markings cannot be removed, repaint trims, housing, etc. to cover markings. Refinish defaced finishes.

C. Labeling abbreviations permitted only as approved.

END OF GUIDE SPECIFICATION SECTION
Equipment “Fed From” Label

TYPE:
- PDM = POWER CENTER MAIN
- PCD = DISTRIBUTION PANEL
- PCB = BRANCH PANEL
- MCC = MOTOR CONTROL CENTER
- TR = TRANSFORMER
- SWA = NON-FUSED SWITCH
- LDF = FAN LOAD
- LDC = COMPRESSOR LOAD

EQUIPMENT DESIGNATION EXAMPLES*

TYPE: XXX—XXXX—XXX

1st TWO DIGITS = AREA DESIGNATION
- P = POWER, F = FED, C = CONTROL
- 1st TWO DIGITS = FLOOR DESIGNATION
- 2nd TWO DIGITS = WING, BUILDING
- 2nd DIGITS = WING, BUILDING
- 00, 01, 02, 03

ITEM DESIGNATION:
- N = NORMAL
- E = EMERGENCY

- THREE DIGIT ITEM NUMBER
- e.g. N01, E25

CIRCUIT OR CUBICLE #
- e.g. (3), (4,6,8), 1A, 3C

* SEE SD—E—141 FOR PLACEMENT AND SIZING

EQUIPMENT CIRCUIT DESIGNATION EXAMPLES*

EA04—N03—9,11
GG03—N32—4
SF—1
LDF—SE07—E03
fed from
MCC—SE02—E05—3C
EF—14
LDF—SW08—E02
fed from
SW01—E11—6,8,10

NE02—N15—5,7,9
SF—1
LDF—SE07—E03
fed from
MCC—SE02—E05—3C
EF—14
LDF—SW08—E02
fed from
SW01—E11—6,8,10

OR
HP

SD—E—154
Medium Voltage Equipment Labels

**Color Scheme Notes**

<table>
<thead>
<tr>
<th>Power</th>
<th>Background</th>
<th>Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.16kv Emergency</td>
<td>Red</td>
<td>White</td>
</tr>
<tr>
<td>13.8kv Normal</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>2.4kv Normal</td>
<td>Orange</td>
<td>White</td>
</tr>
</tbody>
</table>

1. Use Arial MT Rounded font
2. Center All Lines On Label.
4. Use 3m Vhb Adhesive Or Equivalent.
5. Clean Surface With Alcohol Prior To Application.

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**WARNING**

Arc Flash and Shock Hazard
Appropriate PPE Required

<table>
<thead>
<tr>
<th>Dist in Ft &amp; In</th>
<th>Flash Hazard Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX</td>
<td>cal/cm² Flash Hazard at 1 Ft 6 In</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>List of PPE Required</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>XXX VAC</th>
<th>Shock Hazard when cover is removed</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>XX</th>
<th>Glove Class</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dist in Ft &amp; In</th>
<th>Limited Approach Dist (Fixed Circuit)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dist in Ft &amp; In</th>
<th>Restricted Approach</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dist in Ft &amp; In</th>
<th>Prohibited Approach</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>MM/DD/YYYY</th>
<th>Arc Flash Study Date (IEEE 1584-2004a)</th>
</tr>
</thead>
</table>

Equipment ID (Name): (Place Panel Name Here)
Protective Device: (Name of Upstream Protective Device)

Scenario 1 – Utility (In most cases)

Study Performed By: Firm Name, Telephone #, Date

Sample Arc Flash Warning Label
Basis of Design

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

Background Information

- A Short Circuit and Coordination Study for the Seattle main campus 13.8kV system is available to establish initial available fault current for the power system studies. Fault calculations within this report are finite and are not calculated to all extremes of the primary distribution system. The Engineer shall contact Campus Engineering to determine the available fault levels at the point closest to the point of interest on the distribution system. The Engineer shall base their calculations from the closest known point.

- For branch campuses and facilities not served from the University’s primary distribution system, contact the local utility to establish the initial available fault current.

Design Criteria

- The Consultant shall be responsible for providing design level short circuit calculations to insure that the design and estimates are based on the correct sized equipment.

- The Contractor shall 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:
  1) Verify the equipment specified and being provided is correctly applied.
  2) Calibrate and test the equipment per the settings provided by the Coordination Study.
  3) For substations with spot or distributed network protection, provide calculations and settings to configure the network protection relays.

Design Evaluation

The following information is required to evaluate the design:

- Programming Phase: Statement of design intent for the Power System Studies.

- Schematic Design Phase: Provide design assumptions, including available fault values on the existing system that will be used for the preliminary Short Circuit Study. Outline specifications.


- Construction Document Phase: Finalize the Short Circuit Study and verify the design and the equipment specifications. Complete specifications.

Construction Submittals

- Refer to the Short Circuit & Coordination Studies guide specification.
Related Sections

- Facilities Services Design Guide – Electrical - Short Circuit & Coordination Studies

Products, Materials and Equipment

- Refer to the Short Circuit & Coordination Studies guide specification.

Installation, Fabrication and Construction

- Refer to the Short Circuit & Coordination Studies guide specification.

END OF DESIGN GUIDE SECTION
GUIDE SPECIFICATION

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

ELECTRICAL - SHORT CIRCUIT AND COORDINATION STUDIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

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

B. General

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

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

1.02 QUALIFICATIONS

A. The Contractor shall have the studies performed by or under the supervision, review, and approval of a professional Electrical Engineer holding a current license from the State of Washington.

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

1. Power Systems Engineering
2. Siemens Technical Services
4. Electrotest Inc.
1.03 RELATED SECTIONS

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

B. Inspection, calibration & testing section

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

1.04 REFERENCES

A. Applicable codes, standards, and references:

1. National Electrical Code – NEC
2. Institute of Electrical and Electronic Engineers – IEEE
3. American National Standards Institute – ANSI
4. State and local codes and ordinances

1.05 COORDINATION

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

1.06 SUBMITTALS

A. General

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

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

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

1.08 SCHEDULE

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

> Note to the designer: Coordinate the equipment submittal requirements in the appropriate specifications sections with the requirements noted above.
1.09 MEETINGS

A. Attend meetings with the Owner and/or Owner’s Representative as required to explain the results of the studies and to determine any corrective action that is required.

PART 2 - PRODUCTS

2.01 APPROVED SOFTWARE ANALYSIS TOOLS

A. The Short Circuit Study, Coordination Study, and Arc Flash Calculations shall be performed using the SKM Power Tools for Windows (PTW) software package, with no substitution:

B. SKM PTW software package used shall be the latest available releases.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Perform Power System Protective Device studies.

B. The Contractor shall be responsible for gathering all field information and data needed for the protective device studies.

3.02 ONE-LINE DIAGRAM

A. Provide a one-line diagram from SKM PTW that shows the schematic wiring of the electrical distribution system. Include all electrical equipment and wiring to be protected by the protective devices installed under this project.

1. Key nodes on the one line diagram shall be identified and referenced in the formal report. The one-line diagram shall include the following specific information:

   a. X/R ratios, utility contribution, and short circuit values (asymmetric and symmetric) at the bus of the main switchboard, and all downstream equipment containing overcurrent devices

   b. Breaker and fuse ratings

   c. Transformer KVA and voltage ratings, percent impedance, X/R ratios, and wiring connections

   d. Voltage at each bus

   e. Identifications of each bus

   f. Conduit material, feeder sizes, and length

   g. Calculated short circuit current

   h. Arch Flash hazard/risk categories
3.03 SHORT CIRCUIT STUDY

A. Assumptions for Short Circuit Study calculations:

<table>
<thead>
<tr>
<th>Fault Description</th>
<th>Amperes</th>
<th>X/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-phase fault*</td>
<td>32.4kA</td>
<td>11</td>
</tr>
<tr>
<td>L-G fault</td>
<td>2kA (resistance limited)</td>
<td></td>
</tr>
</tbody>
</table>

* The three-phase fault level is a ½-cycle symmetrical value, which includes motor contribution and operation of all on-site generators. For purposes of calculating short circuits for devices with ½-cycle response, use this value as a steady-state quantity.

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

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

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

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

3.04 COORDINATION STUDY

A. Prepare coordination curves to determine the required settings of protective devices to assure selective coordination.
   1. Graphically illustrate, on a log-log scale, that adequate time separation is provided between existing and supplied series devices.
   2. Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices will be clearly depicted on one sheet.
   3. Utilize original SKM 8½" x 11" #8511 paper for curve plotting.
4. Derive settings for new protective devices in consideration of existing upstream protective device settings, and optimize system coordination in light of this constraint.

5. Where the upstream device characteristics do not allow reasonable coordination with new equipment, identify the problem and the recommended resolution in a letter to the Project Manager prior to submitting the coordination study.

B. The following specific information shall also be shown on the coordination curves:

1. Device identifications
2. Settings and current transformer ratios for curves
3. ANSI damage curves for each transformer
4. Melting and clearing fuse curves
5. Cable damage curves
6. Transformer inrush points
7. Maximum short-circuit cutoff point
8. Simple one-line diagram for the portion of the distribution system that the coordination curves are depicting

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

D. Develop a table to summarize the settings selected for the protective devices. Include in the table the following:

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

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

3.05 Arc Flash Analysis and Hazard/Risk Category Calculation per NFPA 70E

A. Perform Arc Flash Analysis and determine Hazard/Risk categories at distribution points per NFPA 70E and show them on one-line diagrams.
3.06 COORDINATION, SHORT CIRCUIT STUDY AND ARC FLASH ANALYSIS

A. Analyze the short circuit calculations, and highlight any equipment that is determined to be underrated as specified or not coordinated. Propose approaches to effectively protect the underrated equipment. The Engineer will take major corrective modifications under advisement and the Contractor will be given further instructions.

B. After developing the coordination curves, highlight areas lacking coordination. Present a technical evaluation with a discussion of the logical compromises for best coordination.

C. Provide labels showing Arc Flash Hazard/Risk Categories to be affixed on all distribution points such as transformers, switchboards, MCCs, VFDs, disconnect switches, etc. See section 16AA, Electrical Identification, for a sample "Arc Flash Warning Label".

D. In addition to the O&M requirements, provide 1 hardcopy and 2 PDF electronic copies of the reports on CD. Also provide a CD of the SKM PTW studies for delivery to University of Washington Campus Engineering. Provide the following immediately upon final completion of the Power Systems Protective Device Studies:

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

END OF GUIDE SPECIFICATION SECTION
Basis of Design

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

Design Criteria

- Edit attached Inspection, Calibration and Testing guide specification, as required, to meet the project requirements.
- 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.

Design Evaluation

The following information is required to evaluate the design:

- **Programming Phase**: In general terms, define the electrical testing requirements.
- **Schematic Design Phase**: Description for electrical testing requirements. Outline specifications.
- **Design Development Phase**: Draft specifications.
- **Construction Document Phase**: Complete specifications.

Submittals

- Refer to attached guide specification Inspection, Calibration and Testing.

Related Sections

- Facilities Services Design Guide – Electrical – Commissioning Support

Installation, Fabrication and Construction

- Refer to attached Inspection, Calibration and Testing guide specification.

END OF DESIGN GUIDE SECTION
GUIDE SPECIFICATION

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

ELECTRICAL – INSPECTION, CALIBRATION AND TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

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

B. General

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

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

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

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

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

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

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

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

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

E. Pre-approved, subject to the qualifications, third party requirements and association restrictions stated in this section:
   1. Siemens Technical Services
   2. Sigma Six Inc
   3. Electrotest, Inc.

1.03 RELATED SECTIONS

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

B. Power System Protective Device Studies

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

1.04 REFERENCES

A. Applicable codes, standards, and references:
   1. All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise in this section.
      b. National Electrical Manufacturer's Association – NEMA
      d. Institute of Electrical and Electronic Engineers – IEEE
      e. American National Standards Institute – ANSI

g. State and local codes and ordinances

h. Insulated Power Cable Engineers Association – IPCEA

i. Association of Edison Illuminating Companies – AEIC

j. Occupational Safety and Health Administration - OSHA 29CFR Part 1910.269

k. National Electrical Code – NEC

l. National Fire Protection Association – NFPA

m. ANSI/NFPA 70: National Electrical Code

n. ANSI/NFPA 70B: Electrical Equipment Maintenance

o. NFPA 70E: Electrical Safety Requirements for Employee Workplaces

p. ANSI/NFPA 78: Lightning Protection Code


r. NFPA 99: Health Care Facilities

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

1.05 COORDINATION

A. Coordinate the Acceptance Testing with the Owner and Owner Representative.

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

1.06 SUBMITTALS

A. General
   1. Submittals shall be in accordance with Conditions of the Contract and Division 01
      Specification Sections.
   2. Submit the ETC qualifications according to this section for approval.
   3. Submit the coordinated test schedule for approval.
   4. Submit detailed test procedures corresponding to the requirements in this section for
      approval. The test procedures shall be detailed test instructions, written with sufficient step-
      by-step information to allow a test to be repeated under identical conditions. List the value for
      all setpoints and acceptable results for each condition tested.
5. Submit a preliminary copy of the hand-written field test results to the Project Engineer and Owner’s Representative no longer than one week after the test is completed.

6. Prior to energization of equipment submit a letter certifying that the electrical installation being energized complies with contract documents, code and proper system operation.

7. The test reports shall be compiled and submitted in formal form with a summary. The report shall be reviewed and stamped by the Professional Electrical Engineer.

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

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

1.08 SCHEDULING

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

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

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

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

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

1.09 MEETINGS

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

1.10 SAFETY AND PRECAUTIONS

A. Safety practices shall include, but are not limited to, the following requirements:

1. Occupational Safety and Health Act of 1970 – OSHA

2. Applicable state and local safety operating procedures

3. National Fire Protection Association - NFPA 70E

B. Tests shall be performed with apparatus de-energized unless otherwise specified (e.g. rotation, phasing).
C. Power circuits shall have conductors shorted to ground by a hotline grounded device approved for the purpose.

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

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

F. The Owner's safety procedures shall be reviewed and understood by the ETC.

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

A. All test equipment shall be furnished by and remain the property of the Contractor.

B. Test instrument calibration
   1. The electrical testing Contractor shall have a calibration program, which maintains all applicable test instrumentation within rated accuracy.
   2. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.
   3. Up-to-date calibration labels shall be visible on all test equipment.

C. Use of torque wrenches
   1. Use calibrated torque wrenches for all bolted connections on buses and power cable terminations. Mark the head of the bolt with a colored marker pen after its being torqued to manufacturer’s recommended value.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Perform acceptance tests in accordance with manufacturer’s recommendations, NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1999.

B. Voltage adjustments shall be in accordance with SCL Standard E1-4.1.

C. The test plan, procedures, test results and reports shall be reviewed, under the supervision of and approved by the ETCs site engineer who is a licensed professional Electrical Engineer.

D. Division of responsibility
   1. The Electrical Contractor shall torque down all accessible bolts, perform routine insulation resistance and continuity tests on branch and feeder circuits and rotational tests for all distribution and utilization equipment, prior to and in addition to tests performed by the ETC specified in this section.
2. The Electrical Contractor shall supply a suitable and stable source of test power to the ETC at each test site. The ETC shall specify these requirements.

3. The Electrical Contractor shall notify the ETC Company when equipment becomes available for electrical tests. Work shall be coordinated to expedite project scheduling.

4. The Electrical Contractor shall clean all the electrical equipment prior to testing by the ETC.

5. The ETC Company shall be responsible for implementing all final settings and adjustments on protective devices and electrical equipment in accordance with the Power System Protective Device Studies.

E. Any questions or concerns identified shall be promptly addressed to the Owner’s Representative.

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

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

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

I. Power systems protective device calibration
   1. Adjustments, settings and modifications
      a. The ETC shall calibrate necessary field settings, adjustments and minor modifications to conform to the coordination study without additional cost. (Examples of minor modifications are trip sizes within the same frame, the time curve characteristics of induction relays, ranges etc.)
         (1) Adjust protective devices to the values provided in the coordination study.
         (2) Test the minimum pickup and delay, ground fault pickup and delay.
         (3) The trip characteristics, when adjusted to setting parameters, shall fall within the manufacturer’s published time-current characteristic tolerance.
   2. The ETC shall verify that the protective devices have been adjusted and set in accordance with the approved protective device study.

J. Acceptance criteria
   1. Each function and test shall be performed under conditions which simulate actual operating conditions as closely as possible.
      a. To that end the Contractor shall provide all necessary materials and equipment and temporary system voltages and currents to simulate fault conditions on the system being tested in order to prove and verify proper operation.
      b. At satisfactory completion of all verified tests, the building electrical system being tested shall be returned to the condition required by the contract documents as a complete and operational system.
   2. The ETC shall perform general inspections at the job site and shall also review the following:
a. Assembly of the accessory equipment, and the interconnecting wiring for control circuits and fire alarm interface

b. General Inspection of the following: Appearance, finish, alignment of doors, covers and similar parts; quality of workmanship; possible shipping and other damage; missing, broken or incorrectly applied devices; loose or missing accessories, bushings or hardware; loose or broken wires; proper installation of all equipment; verify that shop drawings and instructions have been shipped with all equipment and are available.

c. Support of electrical equipment: Inspect and check all electrical equipment for support and seismic bracing.

d. Spare fuses: The ETC Engineer shall inspect and verify spare fuse inventory as specified by Division 16.

3. Testing requirements and procedures

a. The following equipment and systems shall be inspected and tested by the ETC per NETA, manufacturer's instructions, and additional requirements noted.

   (1) Transformers

      (a) All dry type greater than 600 Volt

      (b) Dry type 600 Volt and below

         (i) All transformers greater than or equal to 167 KVA single-phase and 225 KVA 3-phase

      (c) All liquid-filled transformers.

      (d) Tests

         (i) Inspect for physical damage, proper installation, anchorage and grounding.

         (ii) Verify transformer is supplied and connected in accordance with contract documents.

         (iii) Verify that the transformer secondaries have a clockwise phase rotation sequence.

         (iv) Adjust the transformer taps to the nominal system voltages per ANSI C84.1-1989.

   (2) Instrument transformers

   (3) Medium voltage vacuum and air circuit breakers

   (4) Cables

      (a) Medium voltage cable (greater than 600V)

         (i) Apply grounds for a time period adequate to drain all insulation-stored charge - minimum of 24 hours.
(ii) Field test D.C. voltages (kilovolts):

<table>
<thead>
<tr>
<th>Insulation Voltage Class</th>
<th>Acceptance Voltage</th>
<th>Maintenance Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable age &gt; 10 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15kV AC</td>
<td>35kV DC</td>
<td>16kV DC</td>
</tr>
<tr>
<td>5kV AC</td>
<td>15kV DC</td>
<td>2.5kV DC, Megger for 10 minutes</td>
</tr>
</tbody>
</table>

*Prior to splicing new cable into existing, test existing cable at maintenance value. If acceptable, perform splicing, then test old and new together at the maintenance value.

(5) AC and DC motors 10 hp and larger

(6) DC battery systems

(7) Surge arrestors

(8) Reactors

(9) Other utilization equipment

(10) Switches (air and oil)

(a) Verify correct wire bending radii at terminations per wire manufacturer’s recommendations and NEC.

(11) Circuit breakers

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

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

(12) Protective relays and devices

(a) Modify NETA tests according to manufacturer’s recommended testing procedures.

(b) Calibrate and set all relay settings according to the Protective Device Coordination Study.

(13) Ground fault systems

(a) Calibrate and set all ground fault settings according to the Protective Device Coordination Study.
(14) Metering

(a) Modify NETA tests according to manufacturer’s recommended testing procedures.

(b) Calibrate and set all meter configuration settings.

(i) Settings:

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

(15) Emergency off switches

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

(16) Motor control

(a) Motor starters - medium and low voltage

(17) Motor control centers

(a) Verify correct overload heaters are installed.

(18) Variable frequency drives

(a) Electrical tests and inspections to be performed by the manufacturer

(b) Measure and document harmonics at main switchgear or a designated point of common coupling. Confirm measurements meet Division 15 requirements.

(19) Capacitors

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

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

1) Spot or distributed network substations

Special functional testing requirements are detailed below for power substations that are configured as spot or distributed networks. These procedures are based on the typical "Network Control" and “Network Control Power” schematic drawings shown in chapter 16N. Modify procedures as needed to suit the actual network protector system provided. Items a through c shall be completed before scheduling the testing procedure with the University detailed in Items d through dd.
(a) Complete the entire installation for the unit substation including the bus tie to the other two unit substations so the entire substation is functional.

(b) Set all breaker trip unit functions per the coordination study. Remember to configure the spot network relay.

(c) The testing agency shall complete all the required testing and calibration for the entire substation and associated equipment/devices. This includes breakers, relays, and other devices set according to the Short Circuit and Coordination study.

(d) Arrange for the following testing with the UW High Voltage Shop, Campus Engineering and the UW Construction Manager/Coordinator. The network relay and/or switchgear manufacturer representative should be present to assist in the commissioning process. Only the original equipment manufacturer’s authorized service representative shall perform all testing associated with network protector relays. No exceptions to this requirement shall be permitted.

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

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

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

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

(i) Verify control voltage is present.

(j) Rack in the main breaker.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(dd) Repeat the last two steps with the tie breaker open and also the network Auto/Off/Manual selector switch in the off and manual modes.

(20) Emergency systems

(a) Emergency generator systems

(i) Inspect and test per NETA and manufacturer’s recommended start-up and testing procedures.

(ii) Perform resistive and reactive load testing at .8 pf (lagging).

(iii) Test phase rotation to determine compatibility with load requirements.

(b) Automatic transfer switches

(i) Coordinate with Automatic Transfer Switches Section.

(ii) Verify clockwise phase rotation and in-phase transfer between the two sources of power.

(iii) Adjust all timers and other parameters as recommended by the manufacture and the Engineer. A set-up sheet of final parameter settings, which includes spare columns for future modifications, shall be provided inside the enclosure.

(iv) Test all the standard and optional features specified for the transfer switches.

(v) Test load management contacts, both block transfer and load shed. Simulate a load-shed signal from the CMCS (Central Monitoring and Control System) for this purpose.

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

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

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

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

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

(5) Grounding systems

(a) Perform fall-of-potential test on main grounding electrode system per IEEE Standard No. 81. Maximum resistance to ground shall be less than 5 Ohms for commercial or industrial systems and less than 1 ohm for generating or transmission station grounds. If this resistance cannot be obtained with the ground system, notify UW Project Coordinator for further instruction.

(b) Verify that neutrals are grounded only at the main service by removing the service neutral grounding conductor and meggering the neutral bus.

(c) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system-neutral, and/or derived neutral points. Investigate resistance values, which exceed .5 ohm. If this resistance cannot be obtained with the ground system, notify UW Project Coordinator for further instruction.

(6) Convenience receptacles

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

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

(7) Special systems

(a) Service column for operating rooms

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

(8) Isolated power system for operating rooms

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

(i) Measure the impedance (capacitive and resistive) to ground of all conductors with the connection between the line isolation monitor and reference grounding point open. Replace wiring that measures less than 500,000 ohms.
(ii) Measure the potential difference and resistances between the isolated power panel ground bus and the grounding pole of each receptacle and the patient grounding point.

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

(b) Measure system voltage.

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

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

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

(9) Equipotential grounding system for operating rooms

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

(i) Measure the potential difference between the grounding wire to the patient ground jack and any of the bonded exposed conductive surfaces. Correct bonding of any items with a reading over 100 millivolts.

(ii) Measure the resistance between the grounding wire to the patient ground jack and any of the bonded exposed conductive surfaces. Correct bonding of any items with a reading over 0.1 ohms.

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

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

K. Labels

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

L. Retesting

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

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

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

END OF GUIDE SPECIFICATION SECTION
Basis of Design

This section applies to the requirements for electrical commissioning support.

Design Criteria

- Refer to the attached guide specification and modify as required, to meet the project requirements.
- 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 complete prior to the start of the commissioning process.
- 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.
- 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:
  
  1. Verify and document that electrical inspection, calibration, and testing requirements specified in section 16CC are complete.
  2. Functional operation of the emergency power systems including generators and automatic transfer switches (ATSSs). 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:
     (a) Fire Alarm System
     (b) Electrical distribution systems.
     (c) Motor control centers and starters
     (d) Variable frequency drives.
  3. 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.
  4. 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.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**: Description of electrical commissioning requirements. Outline specifications.
- **Design Development Phase**: Draft specifications.
- **Construction Document Phase**: Complete specifications.
Submittals

- Refer to Electrical Commissioning Support guide specification.

Related Sections

- Facilities Services Design Guide – Electrical - Inspection, Calibration and Testing
- Facilities Services Design Guide – Mechanical - Commissioning

Installation, Fabrication and Construction

- Refer to Electrical Commissioning Support guide specification.

END OF DESIGN GUIDE SECTION
GUIDE SPECIFICATIONS

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

ELECTRICAL – COMMISSIONING SUPPORT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Purpose

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

B. General

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

2. Work of Division 16 includes the following:
   a. Start-up and testing of the equipment
   b. Assistance in testing, adjusting and balancing
   c. Operating equipment and systems as required for commissioning tests
   d. Providing qualified personnel for participation in commissioning test, including seasonal testing required after the initial commissioning
   e. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements
   f. Providing operation and maintenance information and as-built drawings to the Test Engineer for verification, organization, and distribution
   g. Providing assistance to the Test Engineer to develop and edit system operation descriptions
   h. Providing training for the systems specified in this Division with coordination by the Test Engineer, Owner's Representative and Commissioning Agent
1.02 RELATED SECTIONS

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

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

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

1.03 REFERENCES

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

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

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

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

1.04 COORDINATION

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

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

C. The ETC (Electrical Testing Contractor) shall coordinate and cooperate in the following manner:
   1. Allow sufficient time before final commissioning dates to complete electrical testing, inspection, and calibration to avoid delays in the commissioning process.
   2. During the commissioning activities, provide labor and material to make corrections when required, without undue delay.

1.05 SUBMITTALS

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

1.06 OPERATIONS AND MAINTENANCE (O&M) MANUALS

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

1.07 SCHEDULE

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

1.08 MEETINGS

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

PART 2 - PRODUCTS

2.01 TEST EQUIPMENT

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

2.02 TEST EQUIPMENT - PROPRIETARY

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

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

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Work prior to commissioning:

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

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

3. Specific pre-commissioning responsibilities of Division 16 are as follows:
   a. Inspection, calibration and testing of the following equipment:
      (1) Transformers
      (2) Primary switchgear and substations
      (3) Secondary switchgear
      (4) Automatic transfer switches
      (5) Emergency power systems
      (6) Electrical distribution systems
      (7) Lighting control systems and lighting level verification
      (8) Fire alarm systems
      (9) Security systems
      (10) Clock system
(11) Special laboratory electrical systems
(12) Variable frequency drives
(13) Uninterruptible power supplies

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

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

3.02 PARTICIPATION IN COMMISSIONING

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

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

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

3.03 WORK TO RESOLVE DEFICIENCIES

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

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

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

1. Experimentation to render system performance will be permitted.

2. If the Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Agent will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities.

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

4. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.04 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

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

1. Initial commissioning will be done as soon as contract work is completed, regardless of season.

2. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

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

1. Heating equipment will be tested during winter design extremes.

2. Cooling equipment will be tested during summer design extremes, with a fully occupied building.

3. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance, as scheduled by the Test Engineer, with three day (minimum) advance notification.

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

1. All equipment and systems effected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance.

2. The Contractor will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.
RECOMMISSIONING

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

3.05 TRAINING

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

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

3.06 SYSTEMS DOCUMENTATION

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

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

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

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

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

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

3.07 MISCELLANEOUS SUPPORT

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

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

END OF GUIDE SPECIFICATION SECTION