DESIGN PRINCIPLES

The Port of Seattle's Facilities and Infrastructure (F&I) department is the single point of responsibility and "owner" of the electrical systems at Sea-Tac International Airport. F&I is responsible for system planning, developing and implementing the capital improvement plan, establishing design standards and managing the electrical systems at Sea-Tac International Airport.

I. Purpose of "Design Principles"

The purpose of this Design Principles document is to assist designers of electrical systems at Sea-Tac International Airport in their understanding of existing medium-voltage, low-voltage and emergency power systems, design goals, technical and non-technical general requirements, information on the design process, and key reference material. For detailed description of electrical design requirements, please refer to the "Electrical Design Procedures" document.

Note that key reference documents, standards and an electrical system description and commentary are listed in the Appendix to these Design Principles.

II. Electrical Standards

All technical design work that is performed at Sea-Tac Airport is required to follow the latest version of the STIA Electrical Standards. These standards are developed and maintained by the Aviation Facilities and Infrastructure Group. These standards contain design guidelines, product data, approved manufacturers and product installation criteria. They are based on the 2004 Construction Specifications Institute (CSI) numbering system. There are also standard details in AutoCAD format that the designer may incorporate into their drawing set. The requirements included in these standards are intended to apply equally to all Port-engineering personnel, Port tenants, Port consulting engineers, and contracting entities performing design and construction at Sea-Tac International Airport.

The design standards, CAD standards and standard details can be found at: https://www.portseattle.org/page/design-standards

It should be noted that close interface with "Special Communications Systems" employed at the Airport, involving various signal and communications systems, will be required on many projects. Designers shall coordinate this interface with the Port and its consultant management representatives to ensure that systems and equipment such as public address and music equipment, voice and data systems, intercommunication equipment and transient voltage suppression equipment are properly designed and specified. See the *Communications Standards* and *Radio Frequency Standards* if applicable to the project.

III. Standard Electrical Guide Specifications

The Port provides standard guide specifications for use by designers on all Airport projects. These guide specifications are more detailed (including specifier prompts) than the STIA Electrical standards and are intended to be edited by the designer for each Port project to comply with specific project requirements and with the STIA Electrical Standards. Electronic copies of these guide specifications can be obtained from the Procurement and Roster Management System on the Port Internet site (Guide Specifications | Port of Seattle (portseattle.org)) for inclusion in construction contract documents.

IV. Record Documents

The Port Engineering Department maintains documentation on as-built architectural, mechanical and electrical systems at the Main Terminal and North and South Satellites for retrieval by others. These files are available in pdf and AutoCAD format and can be obtained by coordinating with the Port Project Manager.

All electrical designs performed and documents prepared on Port and tenant projects at Sea-Tac Airport must comply with Port drafting and layering standards. These standards are available on the Port website under Tenant Construction and Design Reference: http://www.portseattle.org/Business/Construction-Projects/Airport-Tenants/Pages/Reference-Documents.aspx.

V. Application for Connection

An *Application for Connection to the Electrical System* must be completed for each project making a connection to the electrical system; the electrical design engineer should submit the completed application to the project manager who will forward it to F&I for approval. No connections to the electrical system are allowed without an approved application. A copy of this application and associated instruction sheet are located on the Port of Seattle website (https://www.portseattle.org/page/applications-utilities-connections). Note that power connections for temporary construction power require an application and a date of disconnection. Refer to the Electrical Design Procedures document included with the STIA electrical standards for more detailed information on the Application process.

VI. General Requirements

A. Applicable Codes and Industry Standards Include But Are Not Limited To:
   1. National Electrical Code as amended and administered by the State of Washington.
   2. National Electrical Safety Code
   3. State of Washington *Laws, Rules & Regulations for Installing Electric Wires & Equipment (WA 296-45, WAC 296-46 and WAC 296-401)*
   4. State of Washington *Non-Residential Energy Code (WAC 51-11)*
   5. State of Washington Department of Labor and Industries Regulations (L&I)
   6. National Electrical Manufacturers Association
   7. National Fire Protection Association
   8. American National Standards Institute
   9. Underwriters Laboratories Inc.
   10. The Institute of Electrical and Electronics Engineers (IEEE)
   11. National Electrical Contractors Association (NECA)
   12. FAA Regulations
   13. International Building Code (IBC)
   14. International Electrical Testing Association (NETA)
   15. Occupational Safety and Health Administration (OSHA)
   16. Insulated Cable Engineers Association (ICEA)

B. Design Considerations

1. Investigate and verify existing conditions before proceeding with design.
2. Identify and coordinate impacts to Airport operations with stakeholders.
3. Identify and evaluate alternate solutions early in the design process.
4. Develop construction cost estimates and schedules.
5. Energy conservation and efficiency is a critical Port focus. New construction should be designed to use 25% less energy per square foot as compared to all existing airport facilities combined.

C. 7- and 30-Day Electrical Metering
   1. The Port requires 30-day load readings on panels that will have a load increase due to a proposed project. This applies to both Tenant panels and Port panels. Where existing calculated loads are available for a panel, a 30-day load reading will not be needed. The load calculation can be done using verifiable existing calculated load.
   2. Meter readings provide a measure of the current amperage demand present on a panel in fifteen-minute increments for each phase. Generally speaking, 7-day meter readings are adequate for the addition of (1) 20A, 120V circuit. Any higher loads will require a 30-day meter reading.
   3. Meter readings are valid for a period of one year from the day of reading. Past recordings do not exculpate the designer from factoring in additional load that may have been added from the time of the reading and the proposed design.

D. Interdiscipline Coordination
   1. The prime design consultant shall provide a formal inter-discipline coordination check of all contract documents to ensure compatibility of design.
   2. Indicate control-wiring interfaces between systems.

E. Miscellaneous Coordination Items
   1. Division of responsibilities between the Port and tenants will be determined by lease agreements and on a project-by-project basis.
   2. Coordinate size of electrical equipment and equipment arrangements within electrical rooms and spaces as noted in Paragraph X of this document, "Requirements for Electrical Rooms and Spaces."
   3. Make provisions for noise, dust and contaminant control, access control, safety, material staging, outages, and testing on operations and maintenance.
   4. Shutdowns: All shutdowns must be coordinated with the Port Electrical Maintenance Department. Shutdowns may take several weeks of planning in order to coordinate with departments and tenants affected by the power outage. Provide project shutdown and start-up procedures. Submit a Systems and Utility Shutdown Request available on the Port Internet site included with the STIA Electrical Standards.
   5. Electrical Design Review (EDR) meeting attendance as required by F&I. Contact F&I prior to all reviews and final issue of plans to determine if a PEST meeting is required. See Electrical Design Procedures for additional design review information.

F. Listing and Labeling
   1. All electrical equipment shall be listed and labeled by Underwriters Laboratories Inc. or by a third-party evaluator accepted by Washington State Department of Labor and Industries (L&I) Electrical Division. Electrical subassemblies must also be UL listed and labeled.

G. Calculations:

1. Perform system calculations as required including those noted in VIII.E. Load calculations are required by L&I.

H. Redundancy and Resiliency
   1. The South Main Service point is connected to the Alternate Utility Facility (AUF) as a back-up power source in the event of a utility power outage. The AUF is connected directly to the South Main Service point and will automatically restore power within 5 minutes in the event of a utility power outage.
   2. Where Tenants require back-up power for communications systems, tenant shall provide rack-mounted UPSes or a centralized UPS for their communication room. The tenant may also install a manual transfer switch and portable generator connection point if additional back-up power is desired.
      - Tenant connection to a permanent generator is not allowed.

VII. Sea-Tac Airport Electrical Primary Distribution and Emergency System Description

A. Sea-Tac International Airport receives electrical power from Puget Sound Energy (PSE) at two major delivery points, at the North Main Substation and South Main Substation.

B. The existing distribution system at Sea-Tac International Airport distributes power at 12.47 kV and is 4-wire, wye-connected at the North and South Main Substations, but primary feeders operate as a 3-wire delta with a ground conductor. The distribution system is designed such that two primary feeders can serve each transformer load.

C. The Alternate Utility Facility (AUF) is a 30MW generator facility that is directly connected to the South Main Substation. If PSE utility power is lost at the South Main Substation, the AUF will automatically restore power to most of the airport within 5 minutes. AUF does not activate on a localized power outage at a building, concourse, or facility.

D. There are two 1500 kW emergency generators in the Main Terminal complex. Primary emergency distribution is 4,160V 3-wire delta with a ground conductor.

E. There is a 1500kW emergency generator serving the North Satellite. This generator is located near Air Cargo Road and operates at 4,160V.

VIII. Medium-Voltage Primary Distribution Requirements

A. The Port Presently Operates Three Primary Distribution Systems
   1. Normal Power: 12,470 volts, 3-phase, 3-wire, neutral grounded at source
   2. Emergency Power: 4,160 volts, 3-phase, 3-wire, neutral grounded at source
   3. Emergency Power: 480/277 3ø 4-wire, neutral grounded at source

B. General:
   1. The central 4,160V emergency power system serves the passenger terminal and concourses. New emergency loads may be added to the existing system if there is sufficient capacity. New building designs will need to determine if there is adequate capacity on the existing system. If not, new construction will need to add emergency generation. All new emergency systems should be designed at 12.47kV.

2. Non-emergency tenant loads shall not be put on the emergency system.
3. NEC Article 702 Optional standby loads will be permitted on the Sea-Tac emergency power system on a selective basis with F&I, EDR and POS Fire Department approval.
4. Consistent phasing of all primary connections is necessary to ensure safe and operable interconnections between various primary and secondary systems.
5. The sequence of rotation for the 12.47 kV and 4.16 kV POS-owned primary distribution systems is “A,” “B” and “C” as phased to PSE.
   - Note: PSE and SCL do not have the same phase rotation,

C. Existing Sea-Tac International Airport Puget Sound Energy Utility Service Points
   1. This information will be provided to the electrical design engineer on an as-needed basis.

D. Phasing documents – Design shall include a set of drawings detailing and instructing Contractor and Port Maintenance work scope to systematically disable medium voltage feeders, breakers, and/or systems.
   1. Design needs to clearly identify Contractor work scope with medium voltage system.
   2. Design needs to clearly identify Port Maintenance work scope with the medium voltage system. All work associated with switching of existing Port equipment will be performed by Port Maintenance. Contractor is responsible for switching of new and modified systems.
   3. Phasing documents shall identify the breakers, switches, transformers, feeders, switchgears, etc that will be replaced
   4. Phasing documents shall identify impacted switchgear(s) downstream and upstream of the scope of work. Design shall provide mitigation plans to maintain continuous power to affected switchgears.
   5. Phasing documents shall be provided for each affected medium voltage system/feeders.

E. Redundancy
   1. Feeders
      a. Typically provide two separate feeders (one originating at the North Main Substation and one originating at the South Main Substation) to each pad-mounted switch, line-up of switchgear, unit substation or pad-mounted transformer.
      b. Only with F&I approval will it be permissible to provide two separate parallel feeders from a single substation.
   2. Provide double-ended unit substations with dual dry-type transformers, primary switches and secondary tiebreakers unless otherwise approved by F&I.
   3. Transformers
      a. Pad-mounted transformers shall be sized with 30-40% reserve capacity (including fan rating) when initially installed. Note that all pad-mounts shall be provided with fans.
      b. Dry-type and liquid-filled power center transformers shall be sized so that one transformer can carry the entire load by closing the switchgear tie breaker, using transformer fan-cooled ratings.
      c. Dry-type and liquid-filled power center transformers shall be provided with cooling fans.
      d. Refer to Section 261200 - Medium-Voltage Transformers.

e. Where feasible, transformers sized at 3750 kVA and larger shall be fed from a dedicated feeder. A suitable differential protection scheme (ANSI Device 87) shall be provided, whereby activation of the 87 relays shall trip and lockout the upstream drawout circuit breaker or load interrupter switch.

4. Primary taps to medium-voltage feeders shall be made with a primary switch with overcurrent protection for primary outdoor taps use S&C vista switches or F&I approved equal.

F. Underground Distribution
1. Ductbanks
   a. The standard ductbank is reinforced concrete with encased Schedule 40 PVC conduits, 6 inches for medium-voltage primary distribution.
   b. Entries or sweeps into building or equipment shall be rigid galvanized steel. Unreinforced concrete ductbanks are not allowed.
   c. F&I approval is required for any exceptions to a. and b. above.
   d. Profiles of ductbanks are required where underground electrical lines cross other utility lines.
   e. Refer to Red Concrete Section 260543 – Underground Ducts and Raceways for Electrical Systems.
2. Manholes
   a. Size manholes per latest NEC Article 110.V. “Manholes and Other Electric Enclosures Intended for Personnel Entry, All Voltages.”
   b. Seal with electrical duct sealant and/or plug and 100# strength nylon pull cord all ducts entering and leaving manholes and keep as dry as possible.
   c. New medium-voltage switches shall not be located in manholes.
   d. Provide F&I approved signage on all manholes for controlled entry to manholes. Weld manhole ID in 4” letters on top.
   e. Foldouts shall be required in designs for manholes containing medium voltage systems, communications, and manholes/handholes located in the AOA area.
3. Pad-mounted vacuum interrupter switches: Provide bollards for protection of these switches. Refer to Section 261319 - Medium-Voltage Pad Mounted Vacuum Interrupter Switchgear.
4. Cables: The standard size for Port primary service conductors for 12.47 kV and 4.16 kV feeders is 350 kcmil EPR, 105°C, tape shield 12 ½ % overlap 133% insulation, CPE jacketed copper cable. Other cable sizes require F&I approval. Refer to Section 260513 - Medium-Voltage Cables.
5. Surge Protection: Provide utility class surge arresters at all medium-voltage terminations.
6. Monitoring and Data Acquisition Locations, Supervisory locations. Refer to “Power Monitoring and Data Gathering System” paragraph XI.
7. Tests: Perform as stated in XII.

G. Calculations Required
1. Medium-Voltage:
   a. Underground feeder conductor ampacity calculation (based on Neher-McGrath)
   b. Load calculation on the system.
   c. Available fault current calculation at each item of electrical equipment for which withstand and interruption ratings are published.
   d. Voltage drop calculation.

e. Electrical manhole size calculation.
f. Transformer overcurrent protection calculation.
g. Conductor tap calculations as appropriate.
h. Cable pulling tension calculations.

H. Ensure That Following Items are Specified:
1. Ground all metal equipment in manholes.
2. Identification for medium-voltage cable at all accessible locations in manholes, cable vaults and trenches – phase designation, operating voltage, and circuit number. Refer to Section 260553 - Electrical Identification for identification of medium-voltage cables and medium-voltage conduits.
3. Verify that bending radius of cable meets NEC and manufacturer's requirements
4. Emergency conductors and conductors under 600V are not permitted in the same manhole or enclosure as medium-voltage cables, unless enclosed in separate raceway and designed with as much separation as possible.

I. Documentation Required
1. One-line diagrams showing all power system elements and plan drawings showing equipment locations.
2. Test reports as required by code (e.g., ground-fault testing, overcurrent protection, etc.)

IX. Low-Voltage Distribution Requirements

A. Standard Voltages
1. 480V/277V 3∅, 4-wire and 208V/120V 3∅, 4-wire (other voltages only with F&I approval).

B. Redundancy
1. 100% additional transformer capacity at highest rating with fans.
2. Double-ended substations with primary switch and fuse or with medium voltage vacuum circuit breaker as needed to reduce arc flash hazard.
3. 100% additional bus with open tie breaker.

C. Substation Size Guideline
1. 2500 kVA base rating is standard. Other sizes with F&I approval only.

D. Indoor secondary unit substations and power centers (outdoor upon F&I approval).

E. Transformers
1. Dry type indoors, liquid filled outdoor.
2. Tenants are responsible for design of systems from the secondary of outside pad-mounted medium-voltage transformers.
3. Bussed connections to switchgear from transformers with copper windings and terminals.
4. See Section 261200 – Medium Voltage Transformers and 262200 – Low Voltage Transformers.

A. Design Parameters

1. Voltage drop limits: 2% feeders, 3% branch
2. Power factor target: 95% on unit substations
3. Spare breaker capacity guideline: 50% distribution, 30% branch circuit
4. Harmonic content: 5% current total harmonic distortion (THD), or 5% current total demand distortion (TDD)
5. Voltage drop on motor starting less than 10% on any bus

B. Classes of Equipment by Type and Ampacity
1. Lighting and appliance panelboards: 100-600 Amps
2. Power distribution panelboards: 400-1200 Amps
3. Switchboards: 800-2500 Amps
4. Drawout metal clad switchgear: 3200-5000 Amps

C. Required Calculations
1. Fault currents at bus connection for each switchgear lineup, each switchboard, each panelboard and each MCC.
2. Arc Flash hazard level at each switchgear line-up (MV and distribution side), each switchboard, each panelboard and each MCC. The Port maintains a master power system study in EasyPower Software. This model is not complete but is a useful resource for designers. Information from the study is available from F&I upon request.
3. Connected and NEC calculated loads for each panelboard, each switchboard, each MCC and each service. Assume 0.8 PF unless accurate PF is known.
4. Voltage drop: for feeders over 300 feet in length and branch circuits over 100 feet in length for 120 Volts and 200 feet in length for 277 Volts.
5. Selective Coordination: Normal power systems shall be coordinated in the 0.1 second range. Non-coordinated systems may be allowed with F&I approval only.
6. Refer to Port Electrical Standard Section 260573 – Power System Studies for additional information.

D. Power Quality
1. Power factor. Desired power factor is 95%. Provide power factor capacitors on all single-speed induction motors 25 Hp and above except two-speed motors and motors fed by variable frequency drives.
2. Harmonic currents: Provide one-size higher conductor neutrals and double neutral bus in branch circuit panelboards feeding predominately nonlinear loads.
3. Isolate standard motor loads from harmonic sources.
4. Provide 18-pulse variable frequency drives as a minimum to meet IEEE 519.
5. Provide calculated based K-rated and electrostatically shielded dry-type transformers for nonlinear loads.
6. Provide dedicated circuits for all computer and sensitive electronic loads.
7. Provide surge suppression at branch circuits or panelboards serving nonlinear loads. Refer to Section XV titled “Surge Protection and Power Conditioning” below.

E. Documentation
1. Record all “record or as-built” panel schedules on drawings or permanently attach to drawings. Use schedules included in Section 262416 - Panelboards. Include electronic copy of panel schedule spreadsheet with Final and As-Built design documents submitted to Port and F&I.

2. Submit all factory test reports.
3. Provide detailed system operation and maintenance manuals.
4. Provide all "as-built" drawings in AFUS system format at project completion.

F. Target Allowances for Future Capacity
1. Provide 30% branch circuit extra circuit breaker spaces.
2. Provide a minimum of six one-inch empty raceways from recessed panelboards into ceiling spaces.

G. Standby Power Systems
1. UPS Loads: interruption free transfer, capacity per user requirements.
2. Emergency Loads: egress, 10-second load maximum transfer.
3. Legally required Standby Loads: 60 seconds load transfer from normal.
4. Optional Standby Loads: load shedding allowed if F&I approved.
5. Meet FAA and Authority Having Jurisdiction requirements.
6. Connection to the emergency system requires F&I approval.

H. Motors
1. 460-Volt nameplate for 480-Volt systems.
2. 200-Volt nameplate for 208-Volt systems (230-Volt motors shall not be provided for use on 208-Volt systems without F&I approval).
3. All motors rated ½ HP and above shall be 3-phase 460V unless approved by F&I.
4. All motors rated 5HP and above shall be provide with variable frequency drives, soft starts, or equivalent unless approved by F&I.
5. Drive and motor manufacturer for that application shall approve motors for use with variable speed drives. Definite purpose motors specifically designed for VFD application may be used, but note that these motors may not be suitable for across-the-line starting and may not be applicable to VFDs with bypass circuitry.
6. Calculated continuous motor loads for variable frequency drive (VFD) applications should not be above 100% of the VFD continuous current rating.
7. Where VFD are used for motor control, analyze for harmonic distortion and provide correction as necessary.
8. Standard frame for indoor operation is open drip-proof.
9. Standard frame for outdoor operation corrosive areas or areas requiring washdown shall be totally enclosed fan cooled (TEFC) with one-way weep hole valves.
10. Provide heaters for outdoor motors 25 Hp and above which may be idle for periods in excess of 24 hours and under temperatures of less than 32ºF.
11. For non-standard applications, refer to NEMA MG 1 for appropriate frame types.
12. Minimum motor ratings for standard applications:
    a. Open drip-proof: 1.15 service factor with Class B insulation (130°C maximum).
    b. TEFC: 1.15 service factor, with Class F insulation (155° maximum)
    c. NEMA design B and E on VFDs
    d. NEMA Premium efficiency 95% minimum (the highest efficiency available from selected manufacturer).

X. Requirements for Electrical Rooms and Spaces

A. General

1. Provide concrete 3-1/2” housekeeping pads for all floor standing equipment with a flatness tolerance of less than (.2%) point two percent slope with half-inch chamfers.
2. Provide supports and restraints for UBC seismic zone 3 (minimum) requirements for all equipment and raceways. Refer to paragraph titled “Seismic Supports for Electrical Equipment” below for seismic support requirements of electrical equipment.
3. Provide yellow paint striping on floor outlining code-required workspace in utility areas where workspace is accessible to non-electrical personnel. This does not apply to locked electrical rooms accessible only to electrical maintenance personnel.
4. Ensure that pipe and ducts do not enter a room of panelboards, switchboards, switchgear and control assemblies and MCCs unless they serve the room or are approved by F&I. (Latest NEC Ref. NEC Article 110).
   a. All liquid carrying pipes shall be presented and discussed in the EDR and TDR meetings.
5. Provide “dedicated space,” “working space” and exits for low-voltage and medium-voltage equipment complying with latest NEC Article 110 as a minimum.
6. Coordinate keys for locked electrical spaces with Aviation Electrical Maintenance Department.
7. Locate equipment to provide 110-degree door swing minimum.
8. Lighting of 40 footcandles for maintenance is required in all electrical spaces and at least 40 foot-candles on emergency power and 70 foot-candles on normal power in front of switchgear.
9. Exposed raceways are standard in dedicated electrical rooms and closets.
10. Label all raceways leaving electrical rooms and closets as to location of opposite end and load served. Concealed raceways are allowed.

B. Electrical Rooms
1. All low-voltage service entrance equipment shall be in dedicated locked rooms unless approved otherwise by the F&I.
2. All medium-voltage equipment shall be in dedicated locked rooms unless approved otherwise by the F&I.
3. Consider two more sections for MCCs space for future cubicles in new Electrical Rooms.
4. Provide adequate draw-out space with 24 inches minimum to the opposite wall when drawn out.
5. Provide emergency power from the emergency power system for emergency lighting in all electrical rooms. Battery-type emergency lighting shall not be used.
6. Do not provide ceilings in electrical rooms.
7. Ensure that doors to electrical rooms and spaces are adequately sized to accommodate replacement of the largest piece of equipment without substantial dismantling either of equipment or of doors and walls. For power center rooms, the largest piece of equipment is the medium voltage transformer, typically 72”W x 90”H x 72”D.
8. Ensure that haul routes are maintained from electrical rooms to the ramp or to a freight elevator. Haul routes must accommodate the largest piece of equipment in the electrical room. For power center rooms, this is 72”W x 90”H x 72”D.
9. As a general guide, provide an electrical distribution room to serve each 15,000 to 20,000 square feet of new floor space.
10. New equipment in electrical rooms shall be located close to other equipment to optimize use of wall space. Conduit on walls shall be routed above panels. All new

installations should be designed to preserve as much wall space as possible for future equipment.

11. Standard exit door swing for dedicated electrical rooms is “out” using tamper-proof hinges and panic bar hardware for room exit.
12. Positive pressure ventilation of at least 0.1" of water is required in all electrical rooms using filtered supply air.
13. HVAC equipment sized for maximum temperature in electric rooms of 85° degrees. Design supported by calculated values of BTUs generated by the equipment.

C. Electrical Closets
   1. Electrical closets shall meet all “dedicated space” and “working space” requirements of the latest NEC Article 110.
   2. Provide separate closets for power and communication systems.
   3. Electrical closets shall be locked in locations accessible to the general public.
   4. Do not provide structural ceilings in electrical closets unless approved by F&I.
   5. Electrical rooms and closets must provide for installation of panels and equipment and for vertical wiring. In multistory buildings, locate rooms and closets on each floor with risers in direct vertical alignment.

XI. Electrical Power Metering System

D. The Electrical Power metering system will gather and store data from electrical power meters. All new switchgear, switchboards, unit substations, load centers, motor control centers, and metered tenant equipment shall have provisions for being tied into this system. Power meters shall be installed on all 480V panels and/or 480V feeder breakers. Meters shall also be required on 208/120V panels, and multi-point branch circuit meters may be required on 208/120V panels depending on loads served. Meters shall be monitored with web-based software over the Ethernet, without any additions of software or hardware. Meters shall be capable of having data integrated into an Energy Management System. Current transformers shall be compatible with installed meter and shall have 5A full load output current.

E. Medium-Voltage Systems
   1. Designer shall coordinate all new medium-voltage transformer and switchgear installations with F&I to determine specific requirements for both monitoring and control functions.

F. Low-Voltage Systems
   1. Revenue Metering
      a. Accuracy: All devices shall be rated for revenue accuracy criteria (+ or – 1% or better).
      b. Capable of communicating with Airport-wide TCP/IP Ethernet backbone technology custom billing software via the existing Cutler Hammer PowerNet System.
      c. Tenant metering shall be located ahead of tenant-owned transformers, where possible.
   2. Non-Revenue Metering (i.e., Monitoring/Control)
      a. EATON PXM 3000 series or approved equal.

G. Current Sensing Methods (Mains and Feeders – Except Branch Circuit Feeders)
   1. Preferred method: digital trip circuit breakers equipped with digital communications and built-in current transformers (CTs) compatible with Ethernet backbone.
   2. Alternate method: Digital communications via conversion module compatible with Ethernet backbone using separately mounted CTs at individual circuit breakers.

XII. Acceptance Testing

A. General
   1. The following tests shall be conducted, documented with results and submitted for approval. Installation Contractors and independent testing firms shall be equipped to perform the following testing:
      a. Ground resistance testing and completion of "Ground Resistance Test Report."
      b. Low-voltage cable meggering and completion of "Low-Voltage Cable (600V and less) Insulation Megger Test Report."
      c. Medium-voltage cable VLF and Tan Delta testing, including completion of "Medium-voltage Cable Test Report" and "Medium-Voltage Cable Termination Checklist."
      d. Motor testing and completion of "Motor Equipment and Circuit Test Report."
      e. Transformer meggering and completion of "Transformer Equipment and Insulation Test Report."
      f. Miscellaneous field quality control, cleaning, and testing for equipment and electrical systems specified in the technical criteria.
      g. Note that the above testing shall be done before the equipment and systems are energized.
   2. Testing that involves use of instruments other than meggers and volt-ohm-meters (VOMs) shall require an independent Testing Firm. The independent Testing Firm shall function as a specialty testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated, and regularly engaged in the testing of electrical equipment, devices, installations, and systems.
   3. Testing Firm shall meet OSHA criteria for accreditation of testing laboratories or shall be a full member company of the National Electrical Testing Association (NETA).
   4. Acceptable Testing Firms:
      a. Electrical Reliability Services (ERS)
      b. Apparatus Service and Engineering Technology (ASET)
      c. Siemens
      d. Cutler-Hammer Engineering Services and Systems
      e. F&I approved equal
   5. An acceptable Testing Firm experienced in medium-voltage work shall perform all medium-voltage testing.
   6. All transformers, switchgear, MCCs, taps etc shall be infrared scanned while systems are fully energized and under load.

B. Acceptance Testing Consists of the Following:

1. Factory test certification
2. Equipment testing: specific testing on individual equipment.
3. Start-up testing: When a complete system of electrical equipment is being installed as a part of a major project addition, the testing should be done on a system basis to ensure that the system and all its equipment as installed meet specification requirements.
4. Field evaluation: On-site safety evaluations shall be performed on all products not bearing a UL, CSA, ETL Mark but eligible to receive it. This field evaluation must be by one of the above Testing Firms. If the product meets UL, CSA, and/or ETL requirements, a Field Evaluated Product Mark is applied to the product on the spot. Non-UL, -CSA, -ETL pad-mounted transformers, pad-mounted switches or other equipment must be field evaluated by one of the above Testing Firms to comply with F&I requirements.
5. Proof testing: Specialty testing on equipment may be necessary for unusual field conditions or unique installations. For example, all non-UL, CSA, ETL-labeled pad-mounted transformers and pad-mounted switches must be field inspected by one of the above Testing Firms for compliance with ANSI and IEEE standards for labeling.

XIII. Safety

A. The applicable State of Washington safety rules and health standards including but not limited to WAC, WAC-296-45, and WAC 296-24, Part L shall be observed and complied with in every detail by tenants and contractors.

B. All work at Sea-Tac International Airport requires controlling hazardous energy by performing lockout/tagout as defined by WAC 296-24 Part L, Safety Procedures and OSHA 1910.147.

C. See Section 260000 – Electrical Work General for additional safety requirements.

XIV. Grounding

B. Comply with UL 467 and Section 260526 – Grounding and Bonding for Electrical Systems. Refer to IEEE 142-2007 and 1100-2005.

C. General
   1. Provide a low-impedance-ground path for fault currents on all grounded systems that are independent of raceways, enclosures, etc.
   2. Provide equipment-grounding conductors with green-colored insulation for all branch-circuit wiring.
   3. Provide a #4 AWG minimum insulated grounding conductor in raceway from the grounding electrode system for each service location and central equipment location for communication systems.

D. Unit substations, including enclosures of primary and secondary switchgear and the transformer, shall be grounded. Follow IEEE guidelines for substation grounding.

E. Provide an exterior personnel safety copper ground bus bar on the backside of all medium-voltage switchgear approximately 6” above the floor.

F. Ground the steel framework of all new Port and Tenant buildings with a driven ground rod at the base of every corner column and at intermediate exterior columns at distances not exceeding 60’ and not to exceed 10 ohms.

G. Underground Distribution System Grounding
1. Ductbanks: Install a #4/0 AWG bare copper system-grounding conductor embedded in the concrete of each medium-voltage ductbank. Also, provide a ground conductor with each medium-voltage feeder raceway sized per the NEC.
2. Manholes: Install four ground rods in all manholes and vaults close to the wall and set rod depth so 4” will extend above finished floor. Connect all exposed metal parts to a ground rod or to the grounding conductor with #2 AWG copper minimum. Refer to Standard Detail 260526-05 - Manhole Ground Plan.
3. Pad-Mounted Equipment: Install four ground rods and counterpoise around the perimeter of pad for all pad-mounted transformers and pad-mounted switches. Ground noncurrent carrying metal items by connecting them to counterpoise and grounding electrodes with #2 AWG copper minimum.

XV. Surge Protection and Power Conditioning

H. Surge Protection for Low-Voltage Power Systems Serving Electronic Equipment Loads
1. General
   a. Provide solid-state, multiple-stage transient voltage surge suppressors employing no series-connected suppression components for electronic equipment circuits.
   b. Employ OEM matched metal oxide varistor suppression modules.
   c. Provide discrete protection circuitry dedicated to protect L-N, L-L, and L-G. Reduced or partial mode designs are not acceptable.
   d. Parallel configured, threshold suppression network filtering – voltage envelops clamping, electrochemical heat sink encapsulated, with LED indicators, 1 per phase normally “on”, UL 1449 listed.
   e. Refer to Section 264313 – Surge Protection for Low-Voltage Electrical Power Circuits.
2. Main Services, Service Entrance Switchboards:
   a. Peak surge current protection per phase shall be no less than 320,000A/phase.
   b. 7 protection modes minimum.
   c. Interior mounted by panel manufacturer with less than 3 feet of lead, with a goal of 1 foot.
3. Distribution Panels, Motor Control Centers
   a. Peak surge current protection per phase shall be no less than 160,000A/phase.
   b. 10 protection modes (e.g., Aϕ to N, Bϕ to N, Cϕ to N, Aϕ to Bϕ, Bϕ to Cϕ, Cϕ to Aϕ, Aϕ to GND, Bϕ to GND, Cϕ to GND, N to GND)
   c. Interior mounted by panel manufacturer or exterior mounted by Electrical Contractor.
   d. Internal - Installed with less than 3 feet of lead, with a goal of 2 feet.
   e. External - Installed with a maximum of 4’ of lead, with a goal of 2’.
4. Branch Circuit Panels
   a. Peak surge current protection per phase shall be no less than 80,000A/phase.
   b. 10 protection modes

c. Integrally Mounted in Branch Circuit Panels: Integrally mounted surge suppression is the preferred approach at panelboards.
d. Exterior Mounted by Electrical Contractor. Nipple directly to the side of the panel in line with a 3-pole, 30-ampere breaker or fused switch. The breaker used shall be that which is closest to the neutral bus.

I. Power Conditioning for Low-Voltage Systems
1. UPS systems and surge protection should be determined on a case-by-case basis. As a general practice, such protection should be provided for sensitive and/or expensive equipment where interruption is unacceptable. Refer to Section 264313 – Surge Protection for Low-Voltage Electrical Power Circuits.
2. UPS backup for emergency equipment should be carefully evaluated for its necessity.
3. When power-conditioning equipment is specified, the effect of electronics on the input line should be considered and means are taken to prevent power line distortion.

XVI. Seismic Supports for Electrical Equipment

J. General
1. Seismic mounting and bracing of all electrical equipment shall be provided. Meet one or more of the following recommendations for seismic zone 3:
   a. In compliance with manufacturer's recommendations
   b. Based on engineering calculations
2. Seismic restraints and other earthquake damage reduction measures shall be used for all electrical equipment and components.
3. For equipment noted in Paragraph B.2 below, indicate materials, and show designs and calculations for anchorage and bracing, signed and sealed by a registered professional Structural Engineer.

K. Standards
1. Comply with seismic restraint requirements in BOCA and IBC.
   a. Building Officials and Code Administrators International – BOCA National Building Code – latest issue.
   b. International Congress of Building Officials – International Building Code – latest version.
2. Retain a Professional Structural Engineer who is legally qualified to practice in Washington State and is experienced in providing seismic engineering services, including the design of seismic restraints, for the following equipment:
   a. Motor control centers
   b. Switchboards
   c. Switchgear
   d. Unit substations
   e. Pad-mounted switches
   f. Pad-mounted transformers
   g. Dry-type transformers

L. Materials for Restraints
1. Indoor Dry Locations: Steel, zinc plated
2. Outdoors and Damp Locations: Galvanized steel
3. Corrosive Locations: Stainless steel

M. Refer to Port Guide Specification 260548 – Seismic Controls for Electrical and Communication Work.

XVII. Lighting

N. General
1. Energy efficient products shall be used.
2. Lighting design shall take into account natural daylighting. Lighting fixtures shall be controlled in a manner that will allow energy conservation in all areas illuminated by daylighting. Daylight sensing equipment shall be used where appropriate.
3. Time-of-day controls may be combined with occupancy/vacancy sensors to maximize energy efficiency.
4. Performance characteristics shall be considered when choosing a lamp and luminaire combination include; lumen output, maintenance factor, efficiency, glare control, and its initial cost.
5. Custom lighting fixtures may only be used by obtaining written permission from F&I Architecture and Standards Manager.
6. Lamps with improved color rendition attributes shall be used at interior locations.
7. All lighting fixtures shall be UL, CSA, or ETL listed and labeled.
8. The type and quality of lighting must be determined by close communication with the end user of the lighting system. A variety of questions must be answered regarding the visual tasks being performed to best determine the appropriate lighting system.

O. Standards
1. Illuminating Engineering Society of North America Handbook – latest edition.
2. Institute of Electrical and Electronics Engineers, Std. 241- latest

P. Codes and Policies
1. Washington State Administrative Code
2. Washington State Non-Residential Energy Code
3. Americans with Disabilities Act
4. National Energy Policy Act
5. National Electrical Safety Code

Q. Design
1. Foot-candle levels in accordance with Illuminating Engineering Society of North America Handbook recommendations.
2. For lighting calculations use the zone cavity method for indoor applications and the point-to-point method for outdoor applications.
3. Provide Washington State Energy Code Non-Residential Energy Code Lighting Compliance Form with final review submittal.
4. Where feasible, fixtures shall utilize currently stocked lamps. See lamp list in the appendices.
5. When evaluating lighting alternatives perform life cycle cost analysis including energy use, lamp life, and lamp replacement cost including use of ladder, man-lift, or other (design requiring scaffolding for lamp replacement allowed only with F&I

approval). Include intangibles such as color rendering, hazardous materials in lamp or fixture, and ability to be recycled. Provide analysis with final review submittal.

6. The quick pace of technological development will likely render the following fixture recommendations obsolete, but the current preferred fixture types are as follows.
   a. LED fixtures shall be used for lighting of art unless prohibited by artist and approved by F&I. LED fixtures are preferred for lighting of displays, decoration, landscaping, and other small-scale applications where viewers are not exposed to glare, light quality is crucial, or high cost of maintenance offsets capital cost.
   b. Energy efficient fluorescent fixtures are preferred for general interior area illumination due to their efficiency, lamp life, and fixture and lamp cost. Color temperature range from 3500K-5500K, based on specific project needs.
   c. LED are preferred for exterior pole-mounted or wall-pack applications.
7. Safety and security considerations will override efficiency in many instances and preclude the use of automatic dimming or on/off control. Establish parameters early in the design process.
8. Avoid using fluorescent sconces or similar below 8-feet due to potential for interference with radio communications when handsets operate in close proximity.

XVIII. Electrical System Model Software

R. F&I has standardized on *EasyPower* for the electrical system modeling and power system analysis software or F&I approved equal.

XIX. Sustainability

S. Energy is a finite resource that must be conserved if the region is to achieve a sustainable pattern of development. Each project must meet the Washington State Non-Residential Energy code. The Goal of new construction is to be 25% more energy efficient than the existing airport facilities combined. Electrically, this can be achieved by means of
   1. Energy efficient light sources.
   2. Lighting Controls
   3. Measurement and Verification (SFS)
   4. VFD controls

T. The construction of new facilities and the renovation of existing spaces, increase our region's consumption of materials. To approach sustainable patterns of material use, the complete life cycle of a product should be considered where safety and performance of the electrical distribution system allow. Improving the efficiency of use and lowering the overall resource consumption, can be achieved through four strategies:
   1. Minimize material use
   2. Select sustainable sources
   3. Use durable materials
   4. Close the loop through recycling of existing materials and by selecting recyclable new materials

U. There is growing evidence of the negative impact from exposure to multiple environmental toxins present in building materials. The construction of new facilities can create new sources of pollution and environmental impact both inside and outside of buildings. Many building materials create pollutants and contamination during production and the negative impacts occur remotely from the site. Other building materials contain pollutants when they are installed in a building and continue to emit them for long periods of time. The approach to enhancing the environment has three key components:

1. Reduce pollution sources
2. Eliminate contamination
3. Dilute pollution strength

V. Successful strategies for fulfilling these goals and other desirable practices can be found in the U.S. Green Building Council's Leadership in Engineering and Environmental Design (LEED®) program. The Port of Seattle is not currently requiring this program but reviewing projects early in the design phase for inclusion of sustainable features from the program is recommended.

1. Electrical distribution equipment is normally exempt from recycled content considerations due to primary considerations of reliability and safety.

END OF SECTION

APPENDIX

Reference Documents

- Application for Connection to Electrical System
- Electrical Design Procedures
- Port of Seattle Airport Maintenance Systems & Utility Shutdown Request
- Circuit Breaker Trip & Monitoring Requirements
- Manhole Configuration Plan (SK-5)
- Sea-Tac Airport Electrical Primary Distribution and Emergency System Description and Commentary
- STIA Lamp Stock, Latest version