

READ THIS FIRST

Notice to the Design Engineer, this document is part of Facilities and Infrastructure standards for Electrical Systems. Designers are advised to NOT use this template (*.doc) document as part of any project contract documents. Designers shall use the Port of Seattle MasterSpec specifications from the following link:

<https://www.portseattle.org/page/guide-specifications>.

Designers shall edit the corresponding Port's MasterSpec specification to meet the F&I Electrical Standard outlined in this specification. Note that Port's MasterSpec specifications contain specifications and languages for both Aviation and Maritime Divisions. F&I Standards are strictly for Aviation Division, and any Maritime related specs or languages should be removed from the project specifications.

PART 1 - GENERAL

1.1 SUMMARY AND NOTES TO DESIGNER

- A. The extent and location of "Rotary 400 Hz Converters" work is shown in the Contract Documents. This section covers supply of equipment and installation of 60 Hz, 3-phase to 400 Hz, 3-phase rotary converter systems used to provide ground power for commercial aircraft. Included are requirements for the motor generators and special requirements for distribution of 400 Hz power including gateway power boxes.
- B. System includes:
 - 1. 480V, 3-phase, 4-wire input to Motor/Generator set with output of 575V, 3-phase, 4-wire.
 - 2. Generator output is delivered to a standard 600V rated power distribution panelboard or switchboard through standard thermal-magnetic circuit breakers.
 - 3. Distribution panelboard feeds 400Hz power to gate boxes located at passenger loading bridges via field adjustable digital trip circuit breakers. Note that standard thermal magnetic circuit breakers may not trip on faults or short circuits in 400Hz applications. Eaton Digitrip RMS 310 breakers have been satisfactorily applied to 100 and 150 Amp, 400 Hz branch circuits.
 - 4. Outer Jacket: Pressure extruded
 - 5. Gate box at passenger loading bridge delivers 200/115V, 3-phase, 4-wire at 400Hz to aircraft. Gatebox includes stepdown transformer, disconnecting means, circuit protection, controls, contactor and aircraft ground power receptacles and plugs.
 - a. Verify actual power requirements and specification of 200 volt ground power plug / receptacle with end users.
- C. 400Hz branch circuits to individual jetways are typically rated for 100A or 150A.
- D. Paralleling: Paralleling of multiple units requires specialized synchronizing methods, which add complexity to the system. Paralleling of multiple units should be done only when engineering considerations justify the additional complexity, cost and maintenance requirements.
- E. Motor/generator sets shall be horizontal configuration, single shaft. Under special circumstances, single shaft vertical configuration may be used with approval by F&I.

- F. Consider noise attenuation when locating 400Hz units. Rotary units must not be located near workstations or public areas without special noise attenuation treatment.
- G. Consider use of RFI filtering and shielding.
- H. All above ground 400Hz feeders must be routed in aluminum conduit.
- I. Conductors must be copper.
 - 1. Consider voltage drop in sizing conductors. Use voltage drop tables specifically for 400Hz current in copper conductors in non-magnetic raceway.
 - 2. Limit circuit lengths to 1000' maximum to limit voltage drop.
 - 3. Consider use of multi-conductor cable with two parallel conductors per phase, physically displaced 180° to reduce cable inductive reactance. This configuration reduces conductor impedance and voltage drop on 400Hz circuits.
- J. Consider use of line drop compensators for longer gate box branch circuit runs. Specify according to recommendations of a qualified supplier with experience in application of 400 Hz ground power distribution systems.

1.2 **GOVERNING CODES, STANDARDS AND REFERENCES**

- A. FAA regulations
- B. FCC Part 18, CFR Title 47: Radio Frequency Interference Suppression
- C. IEEE 115: Test procedures for synchronous machines
- D. International Electrical Testing Association
- E. MIL-STD-704: Aircraft Electric Power Characteristics
- F. SAE AS5756 General Specification for Cable, Portable, Electrical, Portable.
- G. SAE AS7974 General Specification for Cable Assemblies and Attachable Plugs, External Electrical Power, Aircraft.
- H. NEMA 250 (National Electrical Manufacturers Association) - Enclosures for Electrical Equipment (1000 volts maximum)
- I. NEMA AB 1 (National Electrical Manufacturers Association) - Molded Case Circuit Breakers
- J. NEMA ICS 1: Industrial Control Devices, Controllers and Systems
- K. NEMA ICS 6: Enclosures for Industrial Controls and Systems
- L. NEMA MG 1 (National Electrical Manufacturers Association) - Motors and Generators
- M. NETA ATS (International Electrical Testing Association) - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

- N. NFPA 70 (National Fire Protection Association) - National Electrical Code
- O. NFPA 70, Article 100
- P. OSHA 29 CFR 1910.7
- Q. City of Sea Tac
- R. UL 467: Grounding and Bonding Equipment
- S. UL 485: Molded case Circuit Breakers and Enclosures
- T. UL 506: Specialty Transformers
- U. UL 508: Industrial Control Equipment
- V. FCC Part 18, CFR Title 47: Radio Frequency Interference Suppression.
- W. NEMA MD 1: Wiring Devices.
- X. NEMA 250 (National Electrical Manufacturers Association) - Enclosures for Electrical Equipment (1000 volts maximum).
- Y. NETA ATS (International Electrical Testing Association) - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 **SUBMITTALS**

- A. Submit materials data in accordance with Section 01 33 00 - Submittals. Furnish manufacturers' technical literature, standard details, product specifications, and installation instructions for all products.
- B. Submittals shall include the following:
 - 1. Motor-generator set calculations.
 - 2. Parallel operation studies.
 - 3. Shop Drawings: Indicate outline dimensions, mounting points, interconnecting wiring diagrams, conduit entry locations, and maintenance clearance requirements.
 - 4. Product Data: Submit descriptive literature, ratings, weights, center of gravity and seismic data. Include submittals for the following:
 - a. Motor generator sets
 - b. Miscellaneous controls and ancillary systems
 - c. Protective control devices
 - d. Paralleling control equipment
 - e. Line drop compensators
 - f. Gate boxes with disconnect.
 - 5. Manufacturer's Test Reports: Submit documentation of manufacturers standard test procedures.

6. Provide Seismic Qualification Certification from manufacturer that product is rated to withstand seismic forces as described in Section 26 05 48 – Seismic Controls for Electrical Work. If not available as a standard item from manufacturer, refer to structural engineer for seismic evaluation.
7. Operation and Maintenance Data: Submit maintenance manuals including, but not limited to, the following:
 - a. Coordinate with Division 1 General Requirements.
 - b. Documented ratings of system and of each major component.
 - c. Instructions for starting and operating converters.
 - d. Description of operating limits which may result in hazardous or unsafe conditions, or in equipment damage.
 - e. Routine preventative maintenance and lubrication schedule.
 - f. List of special tools, maintenance materials, and replacement parts, and list of recommended spare parts.
 - g. Instructions for procedures to check, repair, and test equipment during typical malfunctions.
 - h. Complete record drawings, including schematics, wiring diagrams and plans of the completed installation.

1.4 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years experience.
- B. Listing and Labeling: Provide products that are Listed and Labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Authority Having Jurisdiction, and marked for intended use for the location and environment in which they are installed.
 1. All equipment, circuit breakers, panelboards and appurtenances shall be designed and UL listed for 400-hertz system application.
- C. Comply with NFPA 70, as adopted and administered by the Authority Having Jurisdiction.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Transport using manufacturers provisions and per manufacturers recommendations.
- B. Store in dry dust free location and cover completely to exclude contaminants.
- C. Provide temporary heat if condensation is likely to occur.
- D. Ship with accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

1.6 SPECIAL WARRANTY

- A. Comply with Section 01 78 36 - Warranties and Bonds.

- B. Provide five year manufacturer's warranty. Provide certificate of warranty. Start of warranty period shall be date of substantial completion.

1.7 MAINTENANCE SERVICE

- A. Provide service and maintenance contract proposal of rotary converters for three years from Date of Substantial Completion.

1.8 EXTRA MATERIALS

- A. Spare and extra parts shall be identified for all products, but not provided. Include spare parts information in Operation and Maintenance Manuals.
 - 1. Fuses: Provide 2 of each size and type used.
 - 2. Filters: Provide one spare circuit board for each critical circuit.

1.9 SOURCE QUALITY CONTROL

- A. Make completed switchgear available for inspection at manufacturer's factory prior to packaging for shipment. Notify the Port at least two weeks before inspection is allowed.
- B. Allow witnessing of factory inspections and tests at manufacturer's factory or test facility. Notify the Port at least two weeks before inspections and tests are scheduled.

PART 2 - PRODUCTS

2.1 SYSTEM PARAMETERS:

- A. Source Voltage: 480Y/277 Volt, 3-phase, 4-wire.
- B. Output frequency: 400 Hz.
- C. Generating and distribution voltage: 575 Volts, 3-phase, 4-wire.
- D. Aircraft delivery voltage: 200/115 Volts (+ 3% unloaded, - 3% loaded), 3-phase, 4-wire.
- E. System Major Components: The complete 400 Hz aircraft ground power system shall include, but is not limited to, the following components which shall either be UL labeled or approved by Authority Having Jurisdiction.
 - 1. Motor generator set with associated controls and output circuit breaker selected for 400 Hz operation.
 - 2. 600V Distribution panelboards with adjustable digital trip circuit breakers.
 - 3. UL 508 labeled Gate power boxes including:

- a. Delivery of single stinger 90kVA and dual stinger 180kVA output Ratings. See gate schedules for sizing at each gate.
- b. Stainless Steel enclosure.
- c. Stepdown transformer.
- d. Disconnect means.
- e. Circuit protection.
- f. Power contactor.
- g. Controls.
- h. Aircraft ground power receptacles and plugs.
4. Line-drop compensators: UL listed passive capacitive type compensation, sized per manufacturer's recommendations.
5. Gate Box Remote Hand Switch Stations.
6. 400Hz Multi conductor cables. Sizes as indicated in drawings.
7. Radio Frequency Interference (RFI) filtering.
8. 400Hz Ground Cable Hoists
9. 400Hz Ground Cable Cord and Plug assemblies

2.2 **ROTARY CONVERTER**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following: equipment (built to NEMA standards):
 1. MCM Electronics.
 2. Pillar
 3. Cavotech
 4. Or Approved Equal
- B. Product general requirements, motor-driven generator for conversion of 60 Hz power to 400 Hz power:
 1. Horizontal single shaft configuration..
 2. Brushless self-ventilated dripproof configuration.
 3. Individual motor and generator static exciters.
 4. Class F 100% vacuum impregnated epoxy insulation (MIL-E-917).
 5. Three-phase sensing voltage regulation.
 6. Unit mounted UL 508 controls
 7. 100,000 hours calculated meantime between failure.
 8. Noise: 85 DB maximum at 3 feet.
 9. Dynamic balance not to exceed 0.002" double amplitude.
 10. Bearing design life: 150,000 hours.
 11. Input and output circuit breakers.
 12. Output contactor.
 13. Automatic paralleling control:
 - a. Pole alignment detector or other means to assure synchronization of 400 Hz outputs.
 - b. Lockout to prevent closing into phase mismatch between paralleled machines.
 - c. Synchronizing annunciator lights.
 - d. Manual paralleling capability.
 - e. Manual by-pass selector switch.
 - f. Automatic droop control for load balancing within 5% between multiple machines.

- g. Lead/lag circuitry to provide runtime sharing between multiple generators.
 - h. Short cycle prevention circuitry.
 - 14. Consider remote monitoring as a customer selectable option.
- C. Service Conditions:
 - 1. Temperature: [104]°F [maximum.]
 - 2. Altitude: [500] feet above sea level.
- D. Ratings:
 - 1. Power Rating: [400] kW at [100.0] percent power factor.
 - 2. Input Voltage: 480 volts, 60 Hz, 3-phase.
 - 3. Output Voltage: 575 Volts, 400 Hz, 3-phase, 4-wire.
 - 4. Duty Cycle: Continuous.
 - 5. Temperature Rise: 95 °C/40°C ambient.
- E. Motor: 480-Volt, 3-Phase Motor
 - 1. 1200 RPM.
 - 2. Brushless.
 - 3. Synchronous.
 - 4. Hp rating: 120% of rated load.
 - 5. Power factor 1.0 nominal.
 - 6. Static exciter.
 - 7. Overload capacity:
 - a. 110% for two hours minimum.
 - b. 150% for 5 minutes per 24 hour period.
 - c. 300 % for 10 seconds for circuit breaker trip current.
 - d. Efficiency: 88% or better at full load.
 - e. Step load: Voltage dip $\pm 3.5\%$ maximum for step loads of 20% of full load.
- F. 400 Hz, 575-Volt, 3-phase, 4-wire, Generator:
 - 1. Overload capacity:
 - a. 110% for two hours minimum
 - b. 150% overload for 5 minutes per 24-hour period.
 - c. 300% for 10 seconds for circuit breaker trip current.
 - 2. Efficiency: 88% or better at full load.
 - 3. Step Load: Voltage dip $\pm 3.5\%$ maximum for step loads of 20% of full load.
 - 4. Full load application voltage dip 16% maximum
 - 5. 1200 RPM.
 - 6. Brushless.
 - 7. Synchronous.
 - 8. Static exciter.
 - 9. Power factor: 0.8.
 - 10. Frequency regulation: $\pm 1\%$.
 - 11. Voltage adjustment: $\pm 10\%$.
 - 12. Voltage regulation: $\pm 1\%$ no load to full load.
 - 13. Voltage drift: $\pm 0.5\%$ 10° C to 50°C.
 - 14. Total RMS harmonic distortion: 12% max, line-to-line and line-to-neutral.

G. Protective controls:

1. Overvoltage.
2. Undervoltage.
3. Reverse power.
4. Underfrequency.
5. Over/under excitation.

H. Alarms:

1. Undervoltage.
2. Overvoltage.
3. Underfrequency.
4. Underexcitation.
5. Reverse Power.
6. Failure to parallel (if applicable).
7. Provide with both local and remote alarms (via Ethernet cable)

I. 60 Hz metering:

1. Line-to line voltage, three-phase selectable.
2. Amps, three-phase selectable.

J. 400 Hz metering:

1. Line-to-line RMS Voltage, three-phase selectable.
2. Output Amps, three-phase-selectable.
3. Output frequency.
4. Running time meter, 99,999 hours.
5. Line-to-line bus voltage three-phase selectable, for paralleling units.

K. Match motor and generator torque requirements.

L. Accessories:

1. RFI filter.

M. Fabrication:

1. Finish unit using [manufacturer's standard finish].
2. Ship equipment completely assembled, pre-wired and tested.

2.3 ANCILLARY EQUIPMENT

A. Gate Box(s) including the following:

1. The gate box assembly shall be a stand-alone device to provide transformation of 400 Hz, 575 VAC voltage to a nominal 115/200 VAC low voltage power for aircraft use. The gate box shall be supplied with an integral line drop compensator section. The gate box assembly shall be labeled per UL 508.

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- a. Enclosure
 - 1) The gate box cabinet shall be welded #12 gauge 316 stainless steel with stainless steel door piano hinge. The top shall be removable to facilitate complete paint coverage. The unit shall be NEMA 3R compliant. The enclosure shall be designed to provide convection cooling of the interior components without the need for forced-cooling.
 - 2) The enclosure top cover shall have threaded connections for mounting brackets.
 - b. Transformer
 - 1) The gate box shall contain one 0.8 power factor, 400 Hz low impedance dry type step down isolation transformer with 575V delta connected primary and 118/204V wye connected secondary.
 - 2) Insulation shall be class "H" varnish impregnation, two coats as called for under MIL-I-24092. Insulation shall meet UL for 2000 C.
 - 3) The minimum B.I.L. shall be 10,000 volts.
 - 4) The voltage regulation of the line to neutral, no load to full load shall be 0.8% at unity power factor and 1.2% at 0.8 lagging power factor.
 - 5) The transformer shall have a continuous duty rating as indicated on the drawings.
 - c. Line Drop Compensator
 - 1) The Line Drop Compensator is used to eliminate the reactive voltage losses (line drop) in long runs of 400 Hz power distribution. The compensator shall be rated at 180 kVA, 600 volt, 3 phase, 400 Hz continuous load at 0.8 power factor. The compensator shall be capable of correcting an inductive impedance from 6-16% and shall be step adjustable with a minimum of 6 steps.
 - 2) The compensator shall consist of three 400 Hz dry type current transformers, one for each phase (A, B and C). Maximum rating of each transformer shall be 180 amps. Insulation shall be class "H" varnish impregnation, two coats as called for under MIL-I-24092. The transformers shall have multiple taps on the secondary winding for adjustment of the reactive compensation for various combinations of cable lengths and sizes to provide voltage boost from 6% to 16% in 2% increments. The secondary taps shall be positioned in an accessible location to allow adjustment without reaching over or around the primary taps in order to reduce the possibility of coming into contact with the 575 volt power. The taps shall be of the quick connect terminal type. A decal shall show the boost connections. The transformers shall have a 180 amp continuous duty rating. The temperature rise of magnetic components shall not exceed 80°C over a 40°C ambient under rated load conditions.
 - 3) All compensator components shall be factory wired to be an integral part of the gate box.
 - 4) Capacitor voltage rating to be such that if one capacitor fails, the second will withstand the increase in voltage and current. The compensator shall handle a 250% load transient without interruption of service or system degradation.
 - 5) Provide line drop compensation, as determined from the voltage drop calculations, to ensure compliance with MIL-STD-704F to furnish the correct voltage at the aircraft cable plug.
 - d. Controls and Indication
 - 1) A 600V, 3 pole, 250 amp manually operated disconnect isolation switch shall be provided on the fixed portion of the enclosure and shall be lockable with internal and external override.

- 2) The gate box assembly shall be equipped with individual industry standard PC boards, factory adjusted, to provide over voltage, under voltage and overload protection in accordance with MIL-STD-704F.
 - 3) E/F feedback circuit shall use relay logic to insure proper aircraft interlock and safety. This circuit shall also be equipped with an MOV to eliminate any 400 Hz induced voltage from the single jacketed aircraft cable.
 - 4) Gate box shall contain an auxiliary contact for disabling horizontal motion in passenger loading bridge when 400hz power is connected to airplane.
 - e. Gate Box Test Panel
 - 1) The gate box shall contain a hinged metal plate that is painted to match the interior and has a silk screened schematic and component legend. The panel shall contain twenty-seven tests points mounted in the schematic for troubleshooting the following conditions.
 - a) Output voltage of each of the three phases.
 - b) Output voltage of the DC power supply.
 - c) Contactor auxiliary contacts.
 - d) Contactor auxiliary relay.
 - e) Undervoltage relay contacts.
 - f) Overvoltage relay contacts.
 - g) Overload relay contacts
 - h) Overload relay.
 - i) Protective monitor.
 - j) Test switchex to facilitate testing and troubleshooting.
 - k) E/F bypass switch for test purposes when 28VDC power is not available.
 - l) Contactor disable switch to disable the gate box output, but still leave input power to the box enabled.
 - f. Load Contactor Automatic Opening
 - a) The load contactor shall open automatically under the following conditions.:
 - (i) -Under Voltage to meet the parameters of MIL-STD-704F.
 - (ii) -Overload
 - b) After 5 minutes at 125% of full load.
 - c) After 30 seconds at 150% of full load
 - (i) After 0.6 seconds at 200% of full load.
- B. 400Hz Ground Cable Hoist: UL Listed
1. Provide a Cable Hoist assembly to raise the flexible aircraft cable (connected to the gate box or converter mounted on the passenger loading bridge) to a stowed position along the side of the bridge out of the path of moving vehicles. Provide operator controls to allow raising and lowering the cable to power aircraft at the gate.
 2. Enclosure:
 - a. The sheet metal enclosure shall be NEMA 3R outdoor rated,constructed of 12 gauge steel and designed for direct attachment to brackets or the mounting plate of a passenger boarding bridge. External supports, brackets and attaching hardware must be designed to properly support the hoist. Paint hoist to match existing bridge
 3. Motor:

- a. Provide an electric open drip proof gear motor rated at 1/2 HP, 480 VAC, 60 Hz, 3Phase. The gear reducer shall be NEMA rated Class D. Motor shall be capable of operation in both forward and reverse directions.
 - b. Provide a magnetic disc brake to prevent the wire rope drum from unwinding when the hoist is shut off.
 - c. Provide enough horizontal motor clearance from the electrical controller enclosure to inspect/adjust magnetic disc brake assembly.
4. Controls:
 - a. A 600V, 3 pole, 10 amp manually operated disconnect isolation switch shall be provided in the control panel. The panel door shall be interlocked to prevent access unless the disconnect switch is in the OFF position.
 - b. Provide a reversing contactor and control circuitry.
 - c. Circuitry for remote operation by a pushbutton control station mounted on the bridge drive column.
 - d. Provide a 24 Volt adjustable counter to control the IN and OUT limits of the wire rope.
 - e. A step down transformer shall be provided for the low Voltage circuits.
 - f. Provide a single drum with flanges to contain the wire rope.
 - g. Provide 3/16 inch diameter nylon coated stainless steel braided wire rope of sufficient length to raise the aircraft cable level with the underside of the bridge.
 - h. Provide two cast aluminum cable saddles and clamps to attach to the aircraft cable. One clamp is to be attached about 14 feet from the cable head and the second approximately 18 feet from the cable attachment on the bridge. This will allow the aircraft cable to be festooned on the side of the bridge.
 - i. During the "down cycle", the hoist lowers the aircraft cable to a ground handling position. The operator uncouples both swivel clamps from the saddles which allow the aircraft cable to be extended and attached to the aircraft.
 - j. The return of the aircraft cable requires the operator to pull the cable back to a position where the cable clamps can be reattached to the hoist wire rope. The "raise" push-button on the aircraft cable head or the lift column returns the aircraft cable to the stowed position.
 - k. The cable hoist counter disconnects power from the motor when the travel limit, "raise" or "lower," has been reached.
 - l. Provide an auxiliary contact for disabling horizontal motion in the passenger loading bridge when 400hz power is in use. Auxiliary contact in the hoist controller will disable bridge motion when hoist is lowered. The hoist "RAISE" limit switch must have an available integrated customer use NO contact for the 400Hz hoist interlock system. Coordinate with PLB (Passenger Loading Bridge) contractor to ensure proper function.
5. Mounting Kit. Provide top cab mounting kits and side cab mounting kit as required and described in the drawings. JBT must approve of the mounting method used.

C. 400Hz Transmission Cable

1. Multiconductor cable with two parallel conductors for each phase, physically displaced 180° from each other to reduce cable inductive reactance. This configuration has been shown to reduce voltage drop in 400 Hz circuits.
 - a. Planetary wrap construction
 - b. NEC Article 310 Standard
 - c. Color coded

- d. Rated 400Hz, 600VAC
- e. UL Standard 44
- f. Type XHHW-2
- g. Thermally protected

D. 400HZ Ground Power Cable and Connector Assemblies: Size as indicated in the drawings.

1. Cable shall consist of six power conductors twisted around a single neutral conductor. Eighteen control wires, six groups of three wires, are included in the cable bundle.
2. Planetary wrap construction.
3. 400HZ, 600VAC rated.
4. The cable shall meet SAE AS5756 and the cable connector assembly SAE AS7974.
5. Outer Jacket: Pressure extruded rayon-reinforced black neoprene 0.17" (0.43 cm) nominal wall
6. Cables shall have built-in thermal protection device to detect and disconnect output power in an overtemperature situation
7. Connector Head Assembly:
8. Aircraft cable connector shall be a molded material conforming to SAE AS7974. It shall be attached to the aircraft cable with a conical strain relief that is part of the molded connector. The connector shall have a field replaceable GOLD-X thermoplastic nose section.
9. Connector Plugs:
 - a. The power plugs that make contact with the aircraft receptacle shall be silver-coated copper.
 - b. The nose/plug assembly shall be capable of being repaired/replaced without the need of replacing the entire aircraft cable.
10. Aircraft Cable Characteristics
 - a. Minimum Bend Radius: 6.5" (16.5 cm).
 - b. Temperature Range: 65O F to +130O F (-55O C to +65O C).
 - c. Humidity: 0 to 100%.
 - d. Bundling: Single Jacket.
 - e. Cable Marking: Cables shall be marked as required in Article 400-6 in compliance with the requirements of Article 310-11 of the NEC.
 - f. Conductor Identification: The conductors shall be color coded to meet the requirements of Articles 400-22 and 400-23 of the National Electrical Code.
 - g. Voltage Rating: 600 VAC.
 - h. Voltage Imbalance: 0.2V measured at 90kVA, 0.8 power factor, 60 foot length.
 - i. Resistance: minimum 0.157 Ohms per 1000 feet.
 - j. Inductance: maximum 0.0000410 Henries per 1000 feet.

2.4 **SOURCE QUALITY CONTROL**

- A. Port of Seattle and Designer of Record will attend 400Hz MG set manufacturer's facility for MG set factory acceptance testing. Notify Port of Seattle 60 days prior to manufactures test dates. 30 days prior to manufactures test, submit MG set test plan and procedure for Port of Seattle review. Manufactures factory testing shall be conducted during standard work week Monday to Friday and standard work day 7AM to 4PM.

- B. Provide factory inspection and testing reports prior to shipping equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive equipment for compliance with installation tolerances and other conditions affecting performance, including but not limited to, ambient temperature, cooling air circulation, contaminants, and disassembly and maintenance space.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EXISTING WORK

- A. Disconnect and remove abandoned rotary converters.
- B. Clean and repair existing rotary converters, which are to remain or be reinstalled.

3.3 INSTALLATION

- A. Assure anchorage complies with seismic zone 3 requirements. Refer to Section 26 05 48 – Seismic Controls for Electrical Work.
- B. Concrete Bases: 3.5 inches high, reinforced, with chamfered edges. Extend base no less than 3 inches in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Concrete bases shall be leveled to no more than 0.25 inches of deviation for every 3 feet in ALL directions.
 - 2. Contractor shall notify F&I and AV Maintenance prior to concrete pour to measure concrete base and assess base's levelness.
 - 3. Concrete bases shall have smooth finishes. Broom finishes are prohibited.
- C. Verify integrity of equipment grounding conductor.
- D. Route all 400 Hz wiring in aluminum conduit above ground and schedule 40 PVC conduits underground.
- E. Verify integrity of neutral bonding jumper, if required as a separately derived source.
- F. Gate Box Control Cabinet: Terminate input/output of horizontal motion auxiliary relay to passenger loading bridge control panel. Coordinate termination points with PLB contractor if available, otherwise verify terminations with O&Ms.

- G. Cable Hoist Controller: Terminate input/output of horizontal motion auxiliary relay to passenger loading bridge control panel. Coordinate termination points with PLB contractor if available, otherwise verify terminations with O&Ms.

3.4 IDENTIFICATION

- A. Provide labels for enclosures and components as specified in Section 26 05 53 - Electrical Identification.
- B. Identify equipment designation, primary and secondary voltages, primary source, and secondary loads and locations.

3.5 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative with experience and capability to conduct the specialized testing for 400 Hz systems as prescribed by OSHA 29 CFR 1910.7 or a full member of the International Electrical Testing Association.
- B. In general, tests that are performed and certified at the factory need not be duplicated in the field.
- C. Provide test equipment as follows:
 - 1. Certified digital AC voltmeter.
 - 2. Certified clamp-on AC ammeter.
 - 3. Combination resistive and reactive load bank with total capacity of 90kVA (54kVAR reactive and 72kW resistive). Employ two sets of load banks for dual output gate boxes.
- D. Prior to energizing, test installed wire for continuity and faults. Wire will need to pass continuity test to show a complete path is available. If a complete path is not present and/or faults are found, these issues will need to be addressed and retested until no issues are found prior to energizing. Record initial settings of breakers.
- E. On-Site Testing:
 - 1. Check phase rotation with load bank or phase rotation tester and modify wiring if required.
 - 2. Test proper operation of motor generator controls, alarms and metering devices, and proper operation of gate box control buttons.
 - 3. Test proper operation of auto-paralleling function.
 - 4. Verify proper circuit breaker fault isolation and test ground fault on the feeder side of each gate box.
 - 5. Verify over-voltage, under-voltage and overload protection provided by gate box
 - 6. Verify proper operation of reverse power protection system.
 - 7. Check each individual position for no-load and full-load voltage drop using both resistive and reactive loads attached to the output of the aircraft cable and record results.
 - a. Apply load bank to each narrow body position with 90kVA load at 0.80 power factor.
 - b. Test each wide body position at no load, full reactive load, resistive load and 0.80 power factor load with 140kVA load (90kVA on one cable and 50kVA on the other at 0.80 power factor). Reverse loads on the cables and re-test.

8. Use test points on gate box test panel and verify the following:
 - a. Output voltage of each of the three phases.
 - b. Output voltage of the DC power supply.
 - c. Contactor auxiliary contacts.
 - d. Contactor auxiliary relay.
 - e. Under-voltage relay contacts.
 - f. Over-voltage relay contacts.
 - g. Overload relay contacts.
 - h. Overload relay.
 - i. Protective monitor.
9. Inspect and test grounding system for compliance with Section 260526 – Grounding and Bonding for Electrical Systems.

3.6 DEMONSTRATION AND TRAINING

- A. Engage a factory-authorized service representative to train Port maintenance personnel to adjust, operate, and maintain rotary 400 Hz converters.
 1. Train Port maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 2. Review data in maintenance manuals. Refer to Section 01 78 23 - Operations and Maintenance Data.
 3. Schedule training with the Port with at least seven days' advance notice.

3.7 OPERATION AND MAINTENANCE MANUALS

- A. Comply with Section 01 78 23 - Operations and Maintenance Data and Part 1 of this specification.

End of Section

Revision History:

9/15/20 – 2.03.D.6: added thermal protection device for aircraft cable.