

## **SECTION 11 86 02 – SOLID STATE FREQUENCY CONVERTER**

### **PART 1 - GENERAL**

#### **1.1 SECTION INCLUDES**

- A. Solid State Frequency Converter (SSFC).
- B. Work Includes: Designing, manufacturing, testing, furnishing, installing and commissioning 60 Hz to 400 Hz pulse width modulated (PWM) frequency converters rated at a continuous capacity of 90 kVA single output and 180 kVA dual output, to provide 400 Hz power designed to conform to MIL-STD-704F standard for aircraft ground power systems.

#### **1.2 RELATED SECTIONS**

- A. Drawings, General Provisions of the Contract, including General and Special Conditions, as well as General electrical materials and methods of installation apply to work of this section.

#### **1.3 REFERENCES**

- A. The standards and codes applicable to only a portion of the work specified in this section are referenced in the relevant parts or clauses. Standards and codes which are generally applicable to the work of this section, are listed below. The latest approved version or edition, by the authority having jurisdiction, of the following codes, references and standards shall apply. If the authority having jurisdiction has not approved or adopted a particular code, reference, or standard, the latest published edition shall be applicable.
- B. MIL-STD-704 - Aircraft Electrical Power Characteristics.
- C. MIL-STD-461 - Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
- D. NFPA 70 - NFPA 70 National Electrical Code (NEC).
- E. NFPA 70E - Standard for Electrical Safety in the Workplace
- F. IEEE 519 - Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.
- G. Institute of Electrical and Electronic Construction Managers (IEEE) 127 and 519.
- H. ARP-5015 SAE 400 Hertz Ground Power Performance.
- I. DFS-400 (EURO-STANDARD 400 Hz).
- J. Canadian Standards Association (CSA).
- K. NEMA ICS 6 - Enclosures for Industrial Control Devices and Systems.
- L. NEMA ST 20 - Dry Type Transformers for General Applications.

- M. ICS-1 General Standards for Industrial Control and Systems.
- N. ANSI C84.1 - Voltage Ratings for Electrical Power Systems and Equipment.
- O. ATA 101 - Ground Equipment Technical Data.
- P. ISO 1540 - Aerospace Characteristics of Aircraft Electrical Systems.
- Q. ISO 6858 - Aircraft Ground Support Electrical Supplies.
- R. MIL-STD-461 - Electromagnetic Interference Characteristics, Requirements for Equipment.
- S. UL 489 - Circuit Breakers, Molded Case and Circuit Breaker Enclosures.
- T. NEMA National Electrical Manufacturer's Association.
- U. In the event of conflict between a reference and another reference or this specification, request clarifications. All responses are final, and will be at no additional cost to the Owner.
- V. DFW Design Criteria Manual.

#### **1.4 GENERAL**

- A. The SSFC and all components thereof shall be constructed in accordance with all codes and standards and local laws and regulations applicable to the design and construction of this type of equipment, which are generally accepted and used as good practice throughout the industry, including without limitation, NFPA, Underwriter's Laboratories, OSHA, SAE Publications, American National Standards, Military Standards, etc. The design of all parts and subassemblies shall be in accordance with good commercial practice and shall be the responsibility of the manufacturer to assure safe, efficient and practical design in keeping with requirements peculiar to this type system.
- B. The Manufacturer shall be a qualified source, who has been regularly engaged in the Construction Management, manufacturing and installation of commercial aviation power supply equipment and components for a minimum of five (5) years and with a minimum of five hundred (500) units installed.
- C. Qualified manufacturers will have completed no less than ten (10) jobs of similar size and scope within the last five (5) years.
- D. Manufacturers are required to satisfy all requirements of this specification. Should the Manufacturer desire to deviate from any portion, either because the specification is in error, violation of any law or regulation, or is in need of modification to permit a more satisfactory functional and economical design, they must submit a written request for such deviation. The Manufacturer shall not contract, purchase or cause to be delivered, equipment which does not meet all requirements of this document as specified, without obtaining prior written approval.
- E. The Manufacturer shall be responsible for verifying installation locations and methods and shall notify the Representative of any conflicts or code violations prior to manufacture of the SSFC. Modifications to eliminate conflicts or code violations will be coordinated with and approved by the Representative. Modifications shall be made at no additional cost to the Owner.

- F. The Manufacturer shall furnish and install all necessary equipment to provide a complete operable and maintainable unit.
- G. Should alternate mounting configurations or physical attributes, other than those specified herein or indicated on the project drawings, be proposed, manufacturers shall submit alternates to the Representative for approval prior to bid date. Alternate mounting, configurations, or attributes shall be provided at no additional cost to the Owner.
- H. Schedule: See contract drawings for locations/types of SSFC's.
- I. EMI/RFI: Unit shall be designed so as not to affect aircraft radio/navigation equipment. It shall be applicable throughout the entire aircraft radio frequency range. Provisions shall be designed into the unit to protect it from voltage fluctuations which might result from the operation of aircraft radio frequency equipment.

## 1.5 SUBMITTALS

- A. Bid-Submittals: The following submittals shall be included with bid.
  - 1. Alternates per 1.4.G.
  - 2. UL Certification per 1.6.A.
- B. Pre-Manufacture Submittals: The following submittals shall be made as necessary to meet the project schedule, and shall be submitted for approval prior to manufacturing the SSFC units.
  - 1. Product Data and Specifications: Provide manufacturer's data and specifications indicating, as a minimum, input/output voltages and amperages, power rating, physical characteristics, short circuit ratings, dimensions, and enclosure details.
  - 2. Shop Drawings: Provide schematics and interconnection diagrams, indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends. Differentiate between manufacturer-installed wiring and field-installed connections.
  - 3. Installation Details: Provide complete installation details including, without limitation, installation details of all appurtenances. Show installed configuration as well as any pertinent details regarding interface to other equipment and systems, include electrical connection service points.
- C. Pre-Ship Submittals: The following shall be submitted and approved prior to shipping SSFC units to the project site:
  - 1. Factory Test Reports: Indicate factory tests and results and inspection procedures.
- D. Pre-Substantial Completion Submittals: The following submittals shall be submitted and approved prior to 14 days before substantial completion, unless otherwise noted herein.
  - 1. Operation and Maintenance Manuals.
  - 2. Training Program: At least 60 days prior to substantial completion, a training program summary, course syllabus, instructor qualifications, and copy of the training manual shall be submitted for review and approval.
  - 3. Field Commissioning Report: Submit proposed field commissioning report for approval. This approved form shall be utilized for the final field commissioning as specified in Section 3.
- E. Pre-Final Completion Submittals: The following submittals shall be submitted and approved prior to 14 days before final completion.

1. As-Built Drawings. Provide field edited redlined project drawings showing deviations from design documents.
2. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and have been registered with the manufacturer.
3. Field Commissioning Report: A completed field commissioning report for each installed unit as specified herein. Utilize approved form.
4. Training Rosters. Provide training roster with trainee names, dates and types of training, as well as durations.
5. Original software and documentation registered in the Owner's name.
6. Hardcopy and electronic version (compact disk) copies of all programs and settings loaded into any equipment provided hereunder.

#### **1.6 QUALITY CONTROL**

- A. UL Certification: UL or ETL approved by a nationally recognized testing laboratory. Submit certification with bid.

#### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle in accordance with manufacturer's written instructions. Handle carefully to avoid damage to components, enclosure, and finish.
- C. Provide units which do not require disassembly and reassembly because of movement into the final location and follow manufacturer's written instructions.
- D. Deliver equipment as a factory-assembled unit with protective crating and covering.
- E. Store equipment and material in suitable facilities until delivery, installation, and final acceptance by the Owner.
- F. Coordinate delivery acceptance of this equipment at the job site. Offload, store and protect equipment until such time as it has been installed and accepted by the Owner.
- G. Installing contractor shall properly dispose of all waste, including, but not limited to, packaging, crates, etcetera.

#### **1.8 WARRANTY**

- A. Provide a full parts and labor warranty for the new units. Labor warranty shall be performed by factory trained service technicians. Warranty shall run two (2) years from the Date of Substantial Completion. Date of Substantial Completion is defined as the date the system is turned over by the manufacturer, and accepted by the Owner for normal operation, per Section 01 77 00.01 – Closeout Procedure- System Acceptance. All warranty services shall be at the site of the installation. Provider shall be responsible for all travel and sustenance expenses necessary for warranty services.
- B. Shipping and Handling charges for warranty parts shall be the responsibility of the provider.

- C. Warranty Services shall be commenced with on site representation, by qualified repair technicians, within 72 hours from the request of the Owner.

## **1.9 OPERATION AND MAINTENANCE MANUALS**

- A. Provide six (6) bound copies and three (3) electronic copies (external hard drive) for each model SSFC of the approved, comprehensive Operation and Maintenance Manual 14 days prior to Substantial Completion.
- B. The manuals shall fully describe each product, system, or subsystem numbered logically and separated into sections and contained in rigid plastic binders with identification inserted in clear plastic pockets on front and spine of each binder. Manuals shall be assembled in accordance with ATA 101
- C. The content of the manuals shall be limited to information and data that specifically apply to products provided and shall include a general description, theory of operation, routine normal and special operating instructions and sequences. Also included shall be routine maintenance procedures and guides for troubleshooting, disassembly and reassembly instructions, and recommended spare parts list consisting of current prices and sources.
- D. Wiring diagrams and schematics shall be incorporated into the manuals to clearly show features such as controls, switches, instruments, and indicators by name and location.
- E. Special Tools List: Provide a list of any special tools required to perform any field performable maintenance tasks.
- F. Spare Parts List: Provide manufacturer's recommended spare parts list.

## **1.10 TRAINING**

- A. Manufacturer shall provide a complete training program for the Owner's operating, engineering, and maintenance personnel. Training shall include both classroom and hands-on instruction and be of sufficient duration to adequately train personnel to perform on site routine, preventative, and remedial maintenance of the equipment, product or system. Unless noted otherwise, maintenance training shall consist of a minimum of three (3) sessions each consisting of four (4) hours classroom instruction and four (4) hours hands-on instruction for eight (8) personnel, and operator's training shall consist of a minimum of four (4) sessions of one (1) hour duration each hands-on instruction for eight (8) personnel.
  - 1. Operator's training may require some night training at the sole discretion of and without additional cost to the Owner.
- B. Operator training shall be completed no later than seven (7) days prior beneficial use. The manufacturer shall provide maintenance training within 30 days of beneficial use. At least 60 days prior to substantial completion, a training program summary course syllabus, instructor qualifications, and copy of the training manual should be forwarded for review and approval.
- C. Training shall be conducted at the installation site property at the direction of the Owner.
- D. Provide Owner a minimum of seven (7) days notice prior to conducting any training.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURER**

- A. JBT AEROTech (Jetway)
- B. ITW-GSE (Previously Hobart)
- C. Twist Aero
- D. Cavotec (Dabico)
- E. Substitutions: as approved by engineer

### **2.2 BRANDING**

- A. The Owner, or Owner's tenant, reserves the right to provide branding on the exterior sides of the installed equipment and desires that this branding not be diminished by excessively large or aesthetically displeasing branding of individual pieces of equipment. All manufacturers branding, labeling, marking, etcetera, on their products shall be relatively small compared to the overall size of the piece of equipment. The Owner reserves the right to require any non-approved branding removed from finished products at no additional cost.

### **2.3 INPUT**

- A. Input Voltage Rating: 480 Volts (nominal), +/-10%, 3-phase, 3-wire plus ground.
- B. Frequency: 60 Hertz, +/- 5%.
- C. Full Load Amperage:
  - 1. Single Output, 90 KVA Model: 100 amps, maximum.
  - 2. Dual Output, 180 KVA Model: 200 amps, maximum.
- D. Input Power Factor: Unit shall be rated at a minimum of 0.95 power factor at 480 volts and loads of 25% or greater.
- E. Phase Rotation: Any/or, with automatic phase lock for ABC (CBA) input phase rotation or protection and indication for out of phase condition
- F. Inrush Current: Shall not exceed 100% of the input current required when unit is operating at rated load output.
- G. Line Current Balance: From 10% to rated load, the input line current shall not differ by more than 5% from the arithmetic average current in the three (3) input lines.
- H. Harmonic Distortion of Input Current Wave Form: 10 percent THD maximum over load rating of unit.

## 2.4 OUTPUT

### A. 400 Hz

1. Single Output Rating: 90 KVA continuous at 0.8 power factor, lagging.
2. Dual Output Rating: 180 KVA continuous at 0.8 power factor, lagging.
3. Output Voltage: 118/204 Volts RMS, adjustable over a minimum range of +/- 10%, 3-phase, wye, 4-wire, grounded neutral in accordance with the international aircraft electrical power requirements.
4. Phase Voltage Displacement: The phase angle between each of the three output phases will be 120 degrees +/- 1.5 degrees under all rated balanced loads. The phase angle displacement with an maximum unbalanced load of 15% shall be 120 +/- 4.0 degrees.
5. Frequency: 400 Hertz +/- 0.1% and shall not be affected by load.
6. With the SSFC operating at a constant load, a change in ambient temperature up to 55 degrees C in an eight (8) hour period, or as the SSFC stabilizes from cold condition at any load, shall not cause the voltage to change by more than 1% of its rated values.
7. Voltage Waveform Discontinuities: There shall be no evident discontinuities, spikes, or notches in the waveform when viewed on a high frequency oscilloscope.
8. Harmonic Distortion: Output voltage waveform shall not exceed 3% (THD) when measured line-to-line and line-to neutral from no load to and including full rated load. Any single harmonic shall not exceed 2% of the fundamental at steady state voltage.
9. Efficiency: Shall be not less than 90% at any load. No load losses shall not exceed 0.5% of rated load.
10. Voltage Recovery: When initially operating at rated input frequency and rated voltage, and following any sudden change in load of up to 100% of rated load, the transient output voltage shall not deviate beyond the limits of MIL-STD-704F.
11. Voltage Phase Balance: The maximum phase voltage imbalance shall not exceed 3.0V rms, with any applied load from no load up to converter's overload rating. Maximum imbalanced loads shall be limited to within the limitations set forth in MIL-STD-704F, Figure 1.
12. Voltage Modulation: Shall not exceed 0.5% at any steady state condition from no load up to and including 100% of the unit's rated KVA.
13. Voltage Regulation: Shall not exceed 1% of rated voltage from no load to rated load and from rated load to no load. This regulation shall be maintained with the input line voltage variations of +/- 10%.
14. Voltage Trim Adjustment: The output voltage trim adjustment shall be +/- 15% of nominal output span.
15. Overload Capacity: Shall be capable of supplying overloads of up to 115% of rated load continuously, for up to 150% of rated load for five (5) minutes, and for up to 200% of rated load for 10 seconds while maintaining the output voltage within the regulation band.
16. Line Drop Compensation: Shall be 0 to 5% of voltage span and shall be adjustable.
17. Crest Factor: Shall be 1.414, +/- 0.5%.
18. Frequency Modulation: < +/- 0.10% of the period of output voltage wave, unaffected by load.
19. DC content shall not exceed 100 millivolts, under any load condition.

## 2.5 PROTECTION

### A. Input Protection

1. Phase Loss: The SSFC shall detect the loss of any phase and prevent unit from starting or shall shut down if already running.
2. Phase Rotation: The SSFC shall incorporate automatic phase lock circuits, or shall detect incorrect phase rotation and prevent unit from starting.
3. High / Low Input Voltage.

4. Input Circuit Breaker: An internal circuit breaker of suitable size shall provide protection from short circuits and allow maintenance personnel the capability of completely removing power from the unit for maintenance purposes. Input circuit breaker shall be lockable in the off position.
  - a. All primary disconnecting means shall be suitable rated to be capable of withstanding and interrupting fault currents available at the input.
5. Control Circuit Transformers: Shall have fused primaries and secondaries, suitably marked, for protection of all control and indicating devices.

**B. Output Protection**

1. Over/Under Voltage Protection: The SSFC shall detect if over/under voltage exceeds the voltage-time characteristics of MIL-STD-704E, or ISO 6858, and immediately shut down.
2. Overload/Short Circuit:
  - a. The unit shall be isolated from the aircraft load by overload/short circuit protection specifically rated for 400 Hz or DC operation as applicable. The unit shall be capable of detecting overloads in excess of 200% of its rated capacity and shut down within 100msec
  - b. The unit shall be capable of withstanding a bolted phase to ground, bolted phase to phase, or a three phase bolted fault at the output terminals without causing damage to the unit.
3. No Break Power Transfer: Unit shall be designed to provide continuous, trip free operation of aircraft designed for No Break Power Transfer operations during ground servicing at the gate.

## **2.6 CONTROLS**

**A. Remote Control Station:**

1. The control station shall be housed in a NEMA 4X stainless steel enclosure, and shall operate on 24 volts or less and shall be located on the bridge lift column (aircraft side of the bridge), so as to be accessible from ground level. Coordinate this position with all other installed equipment and ancillaries so as to prevent interferences. The station shall be configured as indicated on the design drawings. Modifications to this configuration must be approved by the Representative.
2. The control station shall have a fault-indicator lamp as follows.
  - a. Flash: loss of E&F or 28.5 VDC feedback signal.
  - b. Steady: critical fault, SSFC unit prevented from operating.

**B. Voltage Adjustment Device:** A device shall be provided within the unit's enclosure to adjust the output voltage of the unit by +/- 15% while viewing the voltmeter.

**C. Line Drop Compensation:** A means shall be provided to adjust the automatic line drop compensation for an aircraft cable of length from 0 to 100 feet.

**D. Alarm Reset:** A reset pushbutton shall be provided to reset all indicators from cleared alarm signals.

**E. Diagnostic System:** The unit shall be equipped with a complete diagnostic system including alarm messaging indicator. The diagnostic system shall permit testing of all critical circuits during normal operation.



- A. Remote Monitoring: The unit shall use controllers that apply industry standard, open communications Modbus or BACnet protocol. The controllers will be subject to architect and Airport approval. BACnet devices must be BTL listed and must be fully open. All necessary programming tools and licensing for the controllers shall be provided to the Airport. Controllers must be connected by ethernet cable to the Owner's General Services Network (GSN) – complying with the requirements of the Owner's IT department – and integrated to the Owner's Tridium Niagara Building Automation Systems (BAS). The contractor shall provide additional services, including, but not limited to, all system software, programming tools, graphics tools, licenses, and installation support necessary for the integration and configuration of these controllers to the Owner's existing BASs via Owner's approved BAS integrator. The unit controller shall provide the following information for monitoring purposes:
- a. System Available
  - b. System Status (On/Off).
  - c. System Fault

## **2.7 PBB INTERLOCKS**

- A. Unit shall interlock with the PBB to prevent PBB horizontal operation while SSFC unit is operating. Appropriate messages shall be displayed at the PBB operator's console to indicate unit's run status is preventing PBB operations.

## **2.8 METERS AND INDICATORS**

- A. Voltmeter (Digital): The voltmeter shall be capable of displaying, on a single display, input and output voltages, line-to-line and line-to-neutral. The voltmeter shall be calibrated for 400 Hz and shall have an accuracy of +/-2% full scale.
1. This meter may also be used to display line-to-line DC output voltages, or a separate meter may be provided as necessary.
- B. Ammeter (Digital): The ammeter shall be capable of displaying, on a single display, the output current for each phase. The ammeter shall be calibrated for 400 Hz and shall have an accuracy of +/-2% full scale.
1. This meter may also be used to display DC output currents, or a separate meter may be provided as necessary.
- C. Frequency Meter (Digital): The frequency meter shall be capable of displaying, on a single display, the output frequency for the unit. The frequency meter shall be calibrated for 400 Hz and shall have an accuracy of +/-2% full scale.
- D. Status Indicators: Three (3) indicating lights, visible from the designated front of the unit, shall be provided to indicate the following conditions:
1. Power On
  2. Unit Fault
  3. Converter On
  4. Interlock Bypass On
  5. Input Phase Loss or Incorrect Rotation
  6. Interlock Feedback Loss
- E. Lamp Test. A lamp test push-button when depressed shall test all door mounted light indicators and digital display segments.

- F. Elapsed Time Meter: A non-resettable hour meter shall be provided to register total hours equipment is providing a 400 Hz output. Meter shall register to 99,999 hours.
- G. System Indicators: LEDs shall provide indication that all primary circuits and components are operating correctly.
- H. Alarm messaging Indicator: A multi line alpha-numeric readout shall be provided to indicate an internal fault. Fault code shall remain displayed until the unit is reset, and shall automatically be re-displayed upon restoration of power should a power outage occur after unit faults and prior to re-setting of fault. The multi line display can be utilized to provide other indications specified, with exception of the Status Indicators.
- I. Unit shall be equipped with a battery backup sustainable memory function with ten year performance during absence of input power. Memory shall catalog, date stamp and store the last 200 power deliveries and or faults.

## **2.9 PHYSICAL CHARACTERISTICS**

### **A. Design and Construction**

- 1. The unit shall be designed as a modular assembly containing a solid state, 400 Hz frequency converter and 28.5 VDC power supply and all accessories needed to form an operating power supply. Accessibility to all components, modules, and sub-assemblies, shall be maintained.
- 2. The unit shall be designed and constructed so that parts will not work loose in service. It shall be design to withstand the strains, jars, vibration and other conditions incident to shipping, storage, installation and service.
- 3. The converter and inverter sections of the unit shall be grouped for easy inspection or replacement. Each individual module shall be arranged for removal without disassembly of the unit. Control logic printed circuit cards shall be arranged for insertion in a standard card rack with vibration resistant latching mechanisms.
- 4. The phase modules shall be cooled by a long life fan(s) and the air flow shall be filtered and separated from the internal electronic components to provide a separate physically sealed, environmentally clean electronic sub-section. Cooling of the power transformers shall be convection.
- 5. The power transformers shall be mounted in separate compartments from the internal electric components.
- 6. The unit shall be equipped with approved weather tight fittings for all wiring that pass through the weather tight compartments to prevent the entrance of moisture and dust into isolated electronic compartments.
- 7. All major components and sub-assemblies shall be marked or labeled with an identification number or letter code, or both, on or near the device. The code shall be readily visible when examining the unit.
- 8. All wiring terminals shall result in a permanent, secure bond between the wire and terminal. All circuits which continue to field-wired components shall terminate at suitably identified and easily accessible terminal boards.
- 9. Control panel wiring shall be extra flexible, standard type conforming to MIL-W-16878D, or equal. Installation shall be color-coded to requirement of NEMA ICS-1. All wiring shall have ample service loops, shall be formed into neat appearance, and shall be laced tightly. All wiring shall be permanently marked with an indelible process such as wire stamping, slip-on type markers or other approved methods. Wrap around adhesive markers shall NOT be acceptable. Wire markers shall be within 1" of all terminations and shall be readily visible. Wiring bundles shall be adequately supported and installed in the control cabinet in a neat workmanlike manner.

10. Workmanship: The unit, including all parts and accessories shall be fabricated and finished in a workmanlike manner. Particular attention shall be given to freedom from defects, burrs, sharp edges, quality of soldering, welding, brazing, painting, wiring, riveting, alignment or parts and tightness of assembly screws, bolts, etc.
11. Weatherproof schematics shall be installed on the interior of the controller door. Schematics shall include all wiring and devices and shall include all wire numbers. Schematic shall be impervious to grease, water, ice, or other elements that they may be exposed to in an aviation maintenance environment on an active apron with the doors open.
12. External conductors/cables shall be in conduit. Flexible cables outside of the unit will only be allowed where maximum flexibility is required and only in lengths of 48" or less.

**B. Cabinet**

1. The cabinet enclosure shall be designed to be suitable for the intended environmental conditions. The components and sub-assemblies shall be mounted in a suitable NEMA 3R, or IEC IP 54 enclosure.
2. Access doors and covers shall be provided for easy access to all component parts.
3. The control panel shall be mounted within the NEMA 3R enclosure with provisions included for attaching remote controls.
4. The unit shall be designed for lifting and transporting by forklift.
5. Door interlock switches shall be provided to shut down the unit, suitable warning labels or covers shall be provided where internal voltages decay slowly after shutdown
6. Factory fabricated mounting brackets shall be utilized for installation of the unit under the PBB. Design of these brackets shall be such so as to prevent any welding or cutting of the bridge components to facilitate installation. Brackets shall be universal in nature so as to allow for installation on industry standard, commercially available passenger boarding bridges.

**C. Finishes**

1. Case components and final assembly shall be painted and suitably protected from oxidation and corrosion to a color matching the passenger boarding bridge on which it is installed.

**D. Maintainability and Repair**

1. The unit shall have a minimum life expectancy of 20 years and a mean time between failures of 24,000 hours, while operating within the specifications herein at any load up to, and including, rated load.
2. The mean-time-to-repair shall be no greater than 30 minutes at the module level.
3. Replaceable module accessibility shall be consistent with mean-time-to-repair.
4. Test points shall be built into the equipment to permit rapid isolation of defective assemblies, modules, and piece parts, and facilitate alignment, calibration and test.
5. The unit design shall be such that no less than 99% of all faults are correctable at the user level using recommended spare parts.

## **2.10 ENVIRONMENTAL CONDITIONS**

**A. The unit shall successfully operate under the following conditions:**

1. Ambient Temperature Range: -40 degrees F to 131 degrees F.
2. Relative Humidity: 10% to 100% non-condensing.
3. Wind: Up to 80 mph with gusts to 125 mph.
4. Altitude: Up to 7000 feet above mean sea level without derating.

5. Audible Noise: Shall not exceed 70 dBA at a height of 60 inches and a distance of 78 inches.

## **2.11 FACTORY TESTS**

- A. The Manufacturer shall test every unit to assure compliance with the Specifications. Dated and signed certification test sheets shall be submitted as indicated in the Submittals section of this specification. The Owner shall be notified 14 days prior to the date of such tests. The Owner reserves the right to witness tests and request additional tests that show compliance with the Specifications. Tests shall include, but not be limited to, the following:
  1. Operational Checkout:
    - a. Unit shall undergo a high potential test of 2000V for two (2) minutes on the input of the unit to detect wiring errors. Additional checks shall include overtemp alarm, under voltage alarm, hour meter, and fans.
  2. No Load Losses:
    - a. Operate at no load and nominal input voltage. Measure and record input voltage, output voltage, input current, output frequency, and input power factor.
  3. Load Test:
    - a. Operate unit at 50%, and 100% loads. Measure and record output voltage, output frequency, output current, output voltage and input current THD.
  4. Burn-In:
    - a. Before delivery, operate each unit for a minimum of 24 continuous hours.
- B. Should factory tests fail to indicate compliance with specifications, all costs associated with re-testing, including costs associated with Owner's witness services, will be the responsibility of the manufacturer.

## **PART 3 - EXECUTION**

### **3.1 CABINET MOUNTING**

- A. SSFC shall be mounted as indicated in approved submittal drawings.

### **3.2 ELECTROMAGNETIC COMPATIBILITY**

- A. Grounding:
  1. Install grounding conductors as directed by manufacturer and in accordance with the NEC requirements for separately derived systems.
- B. The chassis and enclosure shall be continuously welded for maximum shielding.

### **3.3 EXAMINATION**

- A. Verify/perform the following items or tasks.

1. Air inlets or exhaust louvers are not obstructed
2. Check to be sure that there are no tools or loose objects in the unit.
3. Make a final check of the security of the power connections.
4. Re-install any covers removed during installation.

### **3.4 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. The units shall not hinder or restrict the passenger boarding bridge or ancillary equipment from operating within its full designed operating range.
- C. Arrange installation of cables to provide adequate clearance for service and maintenance.
- D. The unit and cables shall be properly aligned and adjusted before final acceptance.
- E. Wire mesh strain reliefs shall be utilized at aircraft cable termination points.

### **3.5 INTERFACE WITH OTHER WORK**

- A. Installation of unit shall be coordinated with other trades associated with project.

### **3.6 FIELD QUALITY CONTROL**

- A. Inspect for loose connections, proper grounding connections, and latching of circuit boards in card rack.

### **3.7 STARTING EQUIPMENT**

- A. Adjust for proper operation within manufacturer's published tolerances.
- B. Field Tests
  1. The start up personnel shall test every unit to assure compliance with the Specifications. The Owner shall be notified 14 days prior to the date of such tests. Dated and signed Field Commissioning Reports shall be submitted within 14 days of performance of tests. The Owner reserves the right to witness tests and request additional tests that show compliance with the Specifications. Tests shall include, but not be limited to, the following:
    - a. Operational Checkout:
      - 1) Local and remote pushbuttons shall be checked for operation.
      - 2) Correct phase rotation shall be verified by unit's status indicator.
      - 3) E&F circuit interlock and bypass operation shall be verified by unit's status indicators.
      - 4) Lamp Test shall be verified by unit's status indicators.
    - b. No Load:
      - 1) Operate at no load and nominal input voltage. Measure and record input voltage, output voltage(s), and output frequency at aircraft cable plugs.

- c. Load Test:
    - 1) Operate 400 Hz unit output at 50%, and 100% loads. Measure and record output voltage at aircraft cable plugs for each load interval.
  - d. Provide complete functional testing to the satisfaction of the Owner.
- C. Complete all punchlist items.

### **3.8 ADJUSTING**

- A. Adjust line drop compensation to operate with length of aircraft cable installed. Proper test equipment shall be utilized to verify adjustment of line drop compensation circuit.
- B. Operational Voltages:
  - 1. 400 Hz:
    - a. No Load Voltage: 116.0 - 117.0 Volts.
    - b. Full Load Voltage: 115.0 - 116.5 Volts.

### **3.9 CLEANING**

- A. Clean unit from all construction dust and debris prior to start-up.
- B. Touch up scratched or marred surfaces to match original finish.
- C. Protect the installed unit from subsequent construction operations.

**END OF SECTION 11 86 02**