

# **Appendix C**

## **Terminals - UPS Eq. for MPOE Rooms**

### **GUIDE SPECIFICATIONS**

#### **30 kVA**

#### **Three-Phase Uninterruptible Power System**

### **1.0 GENERAL**

#### **1.1 SUMMARY**

This specification defines the electrical and mechanical characteristics and requirements for a continuous-duty three-phase, solid-state, uninterruptible power system (UPS). The UPS shall provide high-quality AC power for sensitive electronic equipment loads.

All references to model numbers and other pertinent information herein are intended to establish standards of performance, quality and construction. These model numbers are based on equipment manufactured by Liebert. Equivalent products may be considered if adequate information is submitted to the specifying engineer for approval beforehand.

#### **1.2 STANDARDS**

The UPS shall be designed in accordance with the applicable sections of the current revision of the following documents. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.

- ASME
- CSA 22.2, No. 107.1
- FCC Part 15, Class A
- IEC 1000-4-5
- ISO 9001
- National Electrical Code (NFPA-70)
- NEMA PE-1
- OSHA
- UL Standard 1778

The UPS shall be UL listed per UL Standard 1778, and shall be CSA certified.

#### **1.3 SYSTEM DESCRIPTION**

##### **1.3.1 Design Requirements - UPS Module**

**A. Voltage.** Input/output voltage specifications of the UPS shall be:

Rectifier Input: 120/208 volts, three-phase, 4-wire-plus-ground.

Output: 120/208 volts, three-phase, 4-wire-plus-ground.

**B. Output Load Capacity.** Specified output load capacity of the UPS shall be 30kVA/24kW at 0.8 lagging power factor.

### **1.3.2 Design Requirements - Battery**

**A. Battery Cells:** Sealed, lead-acid, valve-regulated.

**B. Reserve Time:** 10 minutes at 24kW full load, with ambient temperature of 25°C.

**C. Recharge Time:** to 95% capacity within ten (10) times discharge time.

### **1.3.3 Modes of Operation**

The UPS shall be designed to operate as an on-line, double-conversion, reverse-transfer system in the following modes:

**A. Normal** - The critical AC load is continuously supplied by the UPS inverter. The rectifier/charger derives power from a utility AC source and supplies DC power to the inverter while simultaneously float-charging the reserve battery.

**B. Emergency** - Upon failure of utility AC power, the critical AC load is supplied by the inverter, which, without any switching, obtains power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.

**C. Recharge** - Upon restoration of utility AC power, after a utility AC power outage, the rectifier/charger shall automatically restart, walk-in, and gradually assume the inverter and battery recharge loads.

**D. Bypass** - If the UPS must be taken out of service for maintenance or repair, or should the inverter overload capacity be exceeded, the static transfer switch shall perform a reverse transfer of the load from the inverter to the bypass source with no interruption in power to the critical AC load.

### **1.3.4 Performance Requirements**

#### **1.3.4.1 AC Input to UPS**

**A. Voltage Configuration for Standard Units:** three-phase, 4-wire plus ground.

**B. Voltage Range:** +10%, -20% of nominal.

**C. Frequency:** Nominal frequency  $\pm 5\%$ .

**D. Power Factor:** Up to 0.99 lagging at nominal input voltage and full rated UPS output load.

**E. Inrush Current:** 800% of full load current maximum.

**F. Current Limit:** 125% of nominal AC input current maximum.

**G. Input Current Walk-In:** 20 seconds to full rated input current maximum. Field selectable 5 through 20 seconds.

**H. Current Distortion:** 4% reflected THD maximum at full load.

**I. Surge Protection:** Sustains input surges without damage per criteria listed in IEC 1000-4-5.



## **1.4 ENVIRONMENTAL CONDITIONS**

The UPS shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:

### **A. Operating Ambient Temperature**

UPS Module: 32°F to 104°F (0°C to 40°C).

Battery: 77°F ±9°F (25°C ±5°C).

### **B. Storage/Transport Ambient Temperature**

UPS Module: -4°F to 158°F (-20°C to 70°C).

Battery: -4°F to 92°F (-20°C to 33°C)

### **C. Relative Humidity**

0 to 95%, non-condensing.

### **D. Altitude**

Operating: to 3300 ft. (1000 meters) above Mean Sea Level. Derated for higher altitude applications.

Storage/Transport: to 40,000 ft. (12,200 meters) above Mean Sea Level.

### **E. Audible Noise**

Noise generated by the UPS under any condition of normal operation shall not exceed 54 dBA measured 1 meter from surface of the UPS.

## **1.5 SUBMITTALS**

### **1.5.1 Proposal Submittals**

Submittals with the proposal shall include:

- System configuration with single-line diagrams.
- Functional relationship of equipment including weights, dimensions, and heat dissipation.
- Descriptions of equipment to be furnished, including deviations from these specifications.
- Size and weight of shipping units to be handled by installing contractor.
- Detailed layouts of customer power and control connections.
- Detailed installation drawings including all terminal locations.

### **1.5.2 UPS Delivery Submittals**

Submittals upon UPS delivery shall include a complete set of submittal drawings and one (1) set of instruction manuals that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

## **1.6 WARRANTY**

### **1.6.1 UPS Module**

The UPS manufacturer shall warrant the UPS module against defects in materials and workmanship for 12 months after initial start-up or 18 months after ship date, whichever period expires first.

### **1.6.2 Battery**

The battery manufacturer's standard warranty shall be passed through to the end user.

## **1.7 QUALITY ASSURANCE**

### **1.7.1 Manufacturer Qualifications**

A minimum of twenty year's experience in the design, manufacture, and testing of solid-state UPS systems is required. The system shall be designed and manufactured according to world class quality standards. The manufacturer shall be ISO 9001 certified.

### **1.7.2 Factory Testing**

Before shipment, the manufacturer shall fully and completely test the system to assure compliance with the specification.

## **2.0 PRODUCT**

### **2.1 FABRICATION**

#### **2.1.1 Materials**

All materials of the UPS shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service except as required during factory testing.

The maximum working voltage, current, and di/dt of all solid-state power components and electronic devices shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid-state component sub-assembly shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 95% of their voltage rating at the maximum rectifier charging voltage.

#### **2.1.2 Wiring**

Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code (NFPA 70). All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator.

Provision shall be made for power cables to enter or leave from the top or bottom of the UPS cabinet.

### **2.1.3 Construction and Mounting**

The UPS unit, comprised of an input circuit breaker, rectifier/charger, inverter, static transfer switch and maintenance bypass switch, shall be housed in a single free-standing NEMA type 1 enclosure. Cabinet doors/covers shall require a tool for gaining access. Casters and stops shall be provided for ease of installation. Front access only shall be required for expedient servicing and adjustments. The UPS cabinet shall be structurally adequate and have provisions for hoisting, jacking, and forklift handling.

The UPS cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. The UPS shall be constructed of replaceable subassemblies. Printed circuit assemblies shall be plug connections. Like assemblies and like components shall be interchangeable.

### **2.1.4 Cooling**

Cooling of the UPS shall be by forced air. Low-velocity fans shall be used to minimize audible noise output. Fan power shall be provided by the UPS output. There shall be redundant fans.

The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded.

### **2.1.5 Grounding**

The AC output neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided.

## **2.2 COMPONENTS**

### **2.2.1 Rectifier/Charger**

#### **2.2.1.1 General**

The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to the inverter and for battery charging. The rectifier/charger shall be a solid-state SCR/IGBT type with constant voltage/current limiting control circuitry.

#### **2.2.1.2 AC Input Current Limiting**

The rectifier/charger unit shall be provided with AC input current limiting whereby the maximum input current shall be limited to 125% of the full input current rating. The rectifier/charger shall operate at a reduced current limit mode whenever the critical load is powered from the UPS static bypass circuit such that the maximum UPS input current will not exceed 125% of full load input current. In addition, the rectifier/charger shall have a battery current limit, adjustable from 0 to 25% of the full load input current.

#### **2.2.1.3 Input Current Walk-In**

The rectifier/charger shall contain a timed walk-in circuit that causes the unit to gradually assume the load over a 20-second time interval after input voltage is applied. Walk-in time shall be field selectable for 5 through 20 seconds.

#### **2.2.1.4 DC Filter**

The rectifier/charger shall have a filter to minimize ripple voltage into the battery. Under no conditions shall ripple voltage into the battery exceed 1% RMS. The filter shall be adequate to ensure that the DC output of the rectifier/charger will meet the input requirements of the inverter. The inverter shall be able to operate from the rectifier/charger with the battery disconnected.

#### **2.2.1.5 Automatic Rectifier Restart**

Upon restoration of utility AC power, after a utility AC power outage and prior to a UPS automatic end-of-discharge shutdown, the rectifier/charger shall automatically restart, walk-in, and gradually assume the inverter and battery recharge loads.

#### **2.2.1.6 Battery Recharge**

In addition to supplying power for the inverter load, the rectifier/charger shall be capable of producing battery charging current sufficient to replace 95% of the battery discharge power within ten (10) times the discharge time. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.

#### **2.2.1.7 Overvoltage Protection**

There shall be DC over-voltage protection so that if the DC voltage rises to the pre-set limit, the UPS is to shut down automatically and initiate an uninterrupted load transfer to the static bypass line.

### **2.2.2 Inverter**

#### **2.2.2.1 General**

The term inverter shall denote the solid-state equipment and controls to convert DC power from the rectifier/charger or battery to regulated AC power for supporting the critical load. The inverter shall use Insulated Gate Bipolar Transistors (IGBTs) in a phase-controlled, pulse width modulated (PWM) design capable of providing the specified AC output.

#### **2.2.2.2 Overload Capability**

The inverter shall be capable of supplying current and voltage for overloads exceeding 100%. The inverter is to provide 150% of full load for 1 minute and 125% of full load for 10 minutes. A status indicator and audible alarm shall indicate overload operation. The UPS shall transfer the load to bypass when overload capacity is exceeded.

#### **2.2.2.3 Fault Clearing and Current Limit**

The inverter shall be capable of supplying an overload current of 150% of its full-load rating for one minute. For greater currents or longer time duration, the inverter shall have electronic current-limiting protection to prevent damage to components. The critical load will be transferred to the static bypass automatically and uninterrupted. The inverter shall be self-protecting against any magnitude of connected output overload. Inverter control logic shall sense and disconnect the inverter from the critical AC load without the requirement to clear protective fuses.

#### **2.2.2.4 Step Load Response**

The output voltage shall be maintained to within  $\pm 4\%$  with a 0-to-100% step load change or a 100%-to-0 step load change. The output voltage shall recover to within 1% of nominal voltage within 1 cycle.

#### **2.2.2.5 Voltage Distortion**

For linear loads, the output voltage total harmonic distortion (THD) shall not be greater than 1%. For 100% rated load of 3:1 crest factor nonlinear loads, the output voltage total harmonic distortion shall not be greater than 4%. The output rating is not to be derated in kVA nor kW due to the 100% nonlinear load with 3:1 crest factor.

#### **2.2.2.6 Phase Balance**

Electronic controls shall be provided to regulate each phase so that an unbalanced loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement. With 100% load on one phase and 0% load on the other 2 phases or 100% load on 2 phases and 0% load on the other phase, the voltage balance is to be within 2% and the phase displacement is to be 120 degrees within  $\pm 1$  degree.

#### **2.2.2.7 Fuse Failure Protection**

Power semiconductors in the inverter unit shall be fused with fast-acting fuses, so that loss of any one power semiconductor will not cause cascading failures.

#### **2.2.2.8 Inverter Shutdown**

For rapid removal of the inverter from the critical load, the inverter control electronics shall instantaneously turn off the inverter transistors. Simultaneously, the static transfer switch shall be turned on to maintain continuous power to the critical load.

#### **2.2.2.9 Inverter DC Protection**

The inverter shall be protected by the following disconnect levels:

- DC Overvoltage Shutdown
- DC Undervoltage Warning (Low Battery Reserve), adjustable
- DC Undervoltage Shutdown (End of Discharge)

#### **2.2.2.10 Inverter Output Voltage Adjustment**

The inverter shall use a software control to adjust the output voltage from  $\pm 5\%$  of the nominal value.

#### **2.2.2.11 Output Frequency**

The output frequency of the inverter shall be controlled by an oscillator. The oscillator shall be temperature compensated and hold the inverter output frequency to  $\pm 0.1\%$  for steady state and transient conditions. Drift shall not exceed 0.1% during a 24-hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed 0.1% from the rated frequency.

### **2.2.3 Display and Controls**

#### **2.2.3.1 Monitoring and Control**

The UPS shall be provided with a microprocessor based unit status display and controls section designed for convenient and reliable user operation. A graphical display shall be used to show a single-line diagram of the UPS, and shall be provided as part of the monitoring and controls sections of the UPS. All of the operator controls and monitors shall be located on the front of the UPS cabinet. The monitoring functions such as metering, status and alarms shall be displayed on the graphical LCD display. Additional features of the monitoring system shall include:

- Menu-driven display with pushbutton navigation
- Real time clock (time and date)
- Alarm history with time and date stamp
- Battery backed-up memory



### **2.2.3.2 Metering**

The following parameters shall be displayed:

- Input AC voltage line-to-line
- Input AC current for each phase
- Input frequency
- Battery voltage
- Battery charge/discharge current
- Output AC voltage line-to-line and line-to-neutral for each phase
- Output AC current for each phase
- Output frequency
- Apparent power
- Active power
- Battery time left during battery operation

### **2.2.3.3 Alarm Messages**

The following alarm messages shall be displayed:

- Input power out of tolerance
- Battery charger problem
- Battery failed test
- Low battery warning
- Low battery shutdown
- DC bus overvoltage
- Bypass frequency out of range
- Load transferred to bypass
- Excessive retransfers attempted
- Static switch failure
- UPS output not synchronized to bypass power
- Output undervoltage
- Output overvoltage
- Output overcurrent
- System output overloaded
- Load transferred to bypass due to overload
- Overload shutdown
- Control error
- Critical power supply failure
- Load transferred due to internal protection
- External shutdown (remote EPO activated)
- Fan failure
- Overtemperature shutdown impending
- Overtemperature shutdown

An audible alarm shall be provided and activated by any of the above alarm conditions.

#### **2.2.3.4 Status Messages**

The following UPS status messages shall be displayed:

- Normal operation
- Load on maintenance bypass
- Load on UPS
- Load on static bypass
- System shutdown
- UPS on battery

#### **2.2.3.5 Controls**

UPS start-up, shutdown, and maintenance bypass operations shall be accomplished through the front-panel pushbutton controls. Menu-driven user prompts shall be provided to guide the operator through system operation without the use of additional manuals. Pushbuttons shall be provided to display the status of the UPS and to test and reset visual and audible alarms. A mimic screen shall be available on the LCD screen to depict a single-line diagram of the UPS, with switch positions and power flow.

#### **2.2.3.6 On-Line Battery Test**

The UPS shall be provided with a menu-driven On-Line Battery Test feature. The test shall ensure the capability of the battery to supply power to the inverter while the load is supplied power in the normal mode.

### **2.2.4 Static Transfer Switch**

#### **2.2.4.1 General**

A static transfer switch and bypass circuit shall be provided as an integral part of the UPS. The static switch shall be a naturally commutated high-speed static (SCR-type) device rated to conduct full load current continuously. The switch shall have an overload rating to clear a 20-ampere load branch circuit breaker.

The static transfer switch control logic shall contain an automatic transfer control circuit that senses the status of the inverter logic signals, and operating and alarm conditions. This control circuit shall provide an uninterrupted transfer of the load to an alternate bypass source, without exceeding the transient limits specified herein, when an overload or malfunction occurs within the UPS, or for bypassing the UPS for maintenance.

#### **2.2.4.2 Uninterrupted Transfer**

The transfer control logic shall automatically turn on the static transfer switch, transferring the critical AC load to the bypass source, after the transfer logic senses any of the following conditions:

- Inverter overload capacity exceeded
- Critical AC load overvoltage or undervoltage
- Battery protection period expired
- UPS fault condition

The transfer control logic shall inhibit an automatic transfer of the critical load to the bypass source if any of the following conditions are present:

- Inverter/bypass voltage difference exceeding preset limits
- Bypass frequency out of limits
- Bypass out-of-synchronization range with inverter output

#### **2.2.4.3 Uninterrupted Retransfer**

Retransfer of the critical AC load from the bypass source to the inverter output shall be automatically initiated unless inhibited by manual control. The transfer control logic shall inhibit an automatic retransfer of the critical load to the inverter if one of the following conditions exists:

- Bypass out of synchronization range with inverter output
- Inverter/bypass voltage difference exceeding preset limits
- Overload condition exists in excess of inverter full load rating
- UPS fault condition present

### **2.2.5 Maintenance Bypass Switch**

#### **2.2.5.1 General**

A manually operated maintenance bypass switch shall be incorporated into the UPS cabinet to directly connect the critical load to the bypass AC input power source, bypassing the rectifier/charger, inverter, and static transfer switch.

#### **2.2.5.2 Isolation**

All energized terminals shall be shielded to ensure that maintenance personnel do not inadvertently come in contact with energized parts or terminals. A means to de-energize the static switch shall be provided when the UPS is in the maintenance bypass mode of operation.

#### **2.2.5.3 Maintenance Capability**

With the critical load powered from the maintenance bypass circuit, it shall be possible to check out the operation of the rectifier/charger, inverter, battery, and static transfer switch. When the application calls for the Maintenance Bypass Switch to be bolted to the UPS cabinet, the interconnecting cables are to be provided, precut and prelugged.

### **2.2.6 Battery Power Pack**

The battery power pack shall include sealed, lead-acid valve regulated battery cells housed in a separate cabinet that matches the UPS cabinet styling to form an integral system line-up. Battery cells shall be mounted on slide-out trays for ease of maintenance. A battery disconnect circuit breaker shall be included for isolation of the battery pack from the UPS module. The UPS shall automatically be disconnected from the battery when the battery reaches the minimum discharge voltage level. Casters and leveling feet shall also be provided with the battery power pack cabinet for ease of installation. When the application calls for the battery cabinet to be bolted to the UPS cabinet, the interconnecting cables are to be provided, precut and prelugged.

## **2.2.7 Accessories (Optional Equipment)**

### **2.2.7.1 Optional External Maintenance Bypass Cabinet**

A matching external maintenance bypass cabinet shall be provided to enable the UPS module to be completely isolated from the electrical system while the critical load is powered through the external maintenance bypass line. This optional cabinet shall provide make-before-break operation for transfers to and from the external maintenance bypass line with a single rotary switch. The following components shall be standard: input and output circuit breakers, single rotary switch with auxiliary contacts, inter-cabinet wiring, casters, and leveling feet. Optional voltage matching transformers and isolation transformers are to be offered. This matching cabinet shall bolt to the side of the UPS module with a barrier shield to separate the two cabinets. Only front access shall be required for installation and service.

### **2.2.7.2 Intellislot™ Relay Board**

Five sets of isolated contacts shall be provided to indicate a change of status of the UPS. Contacts are provided for:

- On UPS
- On Battery
- Low Battery
- On Bypass
- Summary

**2.2.7.3 Intellislot™ OC-485:** Intellislot 485 card. The Liebert IntelliSlot® 485 card family delivers Modbus and Liebert proprietary protocol for monitoring and control of your Liebert equipment through Liebert SiteScan Web or your Building Management System.

## **3.0 EXECUTION**

### **3.1 FIELD QUALITY CONTROL**

The following inspections and test procedures shall be performed by factory-trained field service personnel during the UPS startup.

#### **3.1.1 Visual Inspection**

- Inspect equipment for signs of damage.
- Verify installation per drawings.
- Inspect cabinets for foreign objects.
- Verify neutral and ground conductors are properly sized and configured.
- Inspect battery cases.
- Inspect battery for proper polarity.
- Verify all printed circuit boards are configured properly.

### **3.1.2 Mechanical Inspection**

- Check all control wiring connections for tightness.
- Check all power wiring connections for tightness.
- Check all terminal screws, nuts, and/or spade lugs for tightness.

### **3.1.3 Electrical Inspection**

- Check all fuses for continuity.
- Confirm input voltage and phase rotation is correct.
- Verify control transformer connections are correct for voltages being used.
- Assure connection and voltage of the battery string(s).

## **3.2 MANUFACTURER'S FIELD SERVICE**

### **3.2.1 Service Personnel**

The UPS manufacturer shall directly employ a nationwide service organization, consisting of factory trained field service personnel dedicated to the start-up, maintenance, and repair of UPS and power equipment. The organization shall consist of regional and local offices.

The manufacturer shall provide a fully automated national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, and 365 days/year. If emergency service is required, response time shall be 20 minutes or less.

An automated procedure shall be in place to ensure that the manufacturer is dedicating the appropriate technical support resources to match escalating customer needs.

### **3.2.2 Replacement Parts Stocking**

Parts shall be available through an extensive network to ensure around-the-clock parts availability throughout the country.

Recommended spare parts shall be fully stocked by local field service personnel with back-up available from national parts center and the manufacturing location. The national parts center Customer Support Parts Coordinators shall be on-call 24 hours/day, 7 days/week, and 365 days/year for immediate parts availability. Parts from the national parts center shall be shipped within 4 hours on the next available flight out and delivered to the customer's site within 24 hours.

### **3.2.3 UPS Maintenance Training**

Maintenance training courses for customer employees shall be available by the UPS manufacturer. The training is in addition to the basic operator training conducted as a part of the system start-up.

The training course shall cover UPS theory, location of subassemblies, safety, battery considerations and UPS operational procedures. The course shall include AC to DC conversion and DC to AC inversion techniques as well as control, metering, and feedback circuits to the Printed Circuit Board (PCB) level. Troubleshooting and fault isolation using alarm information and internal self-diagnostics should be stressed.

### **3.2.4 Maintenance Contracts**

A complete offering of preventive and full service maintenance contracts for both the UPS system and battery system shall be available. An extended warranty and preventive maintenance package shall be available. Warranty and preventive maintenance service shall be performed by factory-trained service personnel.

**NOTE:** These Guide Specifications comply with the format outlined by the Construction Specifications Institute per CSI MP-2-1 and CSI MP-2-2.