Vertiv™ Liebert® NXL UPS
GUIDE SPECIFICATIONS
Multi-Module Uninterruptible Power System
(Centralized Static Switch)
625kW/625kVA

1.0 GENERAL

1.1 Summary

These specifications describe requirements for an Uninterruptible Power System (UPS) consisting of one or more multi-module UPS units (MMU) and system controls including a system-level bypass static switch (SCC). The UPS shall be designed for maximum availability and high performance. The UPS shall automatically maintain AC power within specified tolerances to the critical load without interruption during failure or deterioration of the AC input power. All performance values specified shall be for the equipment needed to operate at the same voltage as the electrical system, including necessary voltage transformation and load sharing components. The UPS shall be expandable by paralleling additional modules of the same rating to provide for module redundancy or load growth requirements.

The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental and space conditions at the site. The UPS shall include all equipment to integrate the AC power source to the intended load and be designed for unattended operation.

1.2 Standards

The UPS and all associated equipment and components shall be manufactured in accordance with the following applicable standards:

- The UPS shall be UL listed per UL Standard 1778, latest edition, Uninterruptible Power Supplies, and shall be CSA certified.
- The UPS shall be provided with a Short Circuit Withstand Rating label denoting the maximum source fault short circuit current that is applicable to the unit. The withstand rating shall be independently verified by a nationally recognized third-party lab. Self certification shall not be acceptable.
- The UPS shall withstand input surges to both the rectifier and bypass, when configured as a dual-input unit, without damage per the criteria listed in ANSI C62.41, category B3 (6kV). The manufacturer shall provide evidence of compliance and test data upon request.
- The UPS shall comply with FCC Rules and Regulations, Part 15, Subclass B, Class A. This compliance is legally required to prevent interference with adjacent equipment. The UPS shall have a label stating FCC compliance. The manufacturer shall provide evidence of compliance upon request.
- The UPS shall be compatible with the wiring practices, materials and coding in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards. Overcurrent devices provided in the UPS shall include trip functions as indicated on the project drawings. Provisions shall be made in the cabinets to permit installation of input, output and external control cabling, using raceway or conduit for top and bottom access to input, output, bypass and DC connections. Connection cabinets shall provide for wiring gutter and wire bend radius as defined by the NEC and UL.

- The UPS and matching Battery Cabinets shall be certified to the International Building Code (IBC) 2012 with seismic performance of Sds=2.00, Ip=1.5 and z/h=1.0. Optional seismic brackets shall be available from the UPS manufacturer for use in compliance with this certification.
- The Quality System for the engineering and manufacturing facility shall be certified to conform to Quality System Standard ISO 9001 for the design and manufacture of power protection systems for computers and other sensitive electronics.

1.3 System Description

1.3.1 Design Requirements

- The UPS shall be sized to provide a minimum of 625kW and a minimum of 625kVA output.
- The UPS shall be able to power 562.5kW loads with power factors of 0.9 lagging and 0.95 leading.
- Load voltage and bypass line voltage shall be ___VAC, three-phase, three-wire in and out or four-wire in and out. When the bypass is three-wire, the UPS shall be supplied with a main bonding jumper to configure the UPS source as separately derived.
- Input voltage shall be ___VAC, three-phase, three-wire.
- The battery shall support the UPS at 100% rated kW load for at least _____ minutes at 77°F (25°C) at startup.
- The UPS shall have a 12-pulse solid-state rectifier with input filter, with automatic disconnect for input power factor control. The disconnecting level shall be adjustable to allow operation with generators that are sensitive to leading power factor loads.
- The UPS shall be equipped with an input isolation transformer to provide isolation for DC ground faults and an output isolation transformer to allow connection as a separately derived source when a main bonding jumper is installed and the bypass input is three wire.

1.3.2 Modes of Operation

The UPS shall operate as an on-line reverse transfer system in the following modes:

1. Normal

   The critical AC load shall be continuously powered by the UPS inverter. The rectifier/charger shall derive power from the utility AC source and supplies DC power to the inverter while simultaneously float charging the battery. Float charging shall be continuous without cycling to be in compliance with the battery manufacturers' published float service warranty requirements.

2. (Optional) Energy Optimization Mode (Active Inverter Eco-Mode)

   The critical load shall be continuously powered by a method that provides higher efficiency than that provided with normal operation. Battery float charging shall be the same as during Normal operation.

3. Emergency

   Upon failure of utility AC power, the critical AC load shall be powered by the inverter which, without any switching, shall obtain its power from the battery plant. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.

4. Recharge

   Upon restoration of the utility AC source, the rectifier/charger shall power the inverter and simultaneously recharge the battery. This shall be an automatic function and shall cause no interruption to the critical AC load.

5. Bypass

   If the UPS must be taken out of service for maintenance or repair, the static transfer switch shall transfer the load to the bypass source. The transfer process shall cause no interruption in power to the critical AC load. An optional external wrap-around maintenance bypass shall be used to ensure full isolation of the unit for the service of internal components.

6. Battery Unavailable

   If the battery is unavailable, the UPS shall continue to function and meet all of the specified steady-state performance criteria except for the power outage backup time capability.

7. Self-Load Test

   During system commissioning, the charger, battery, inverter and bypass of the UPS module shall be tested at full load without the need for an external load bank. Testing mode shall use the bypass source as the load.

1.3.3 Performance Requirements

The UPS shall be able to support 100% critical load and maintain full battery charging with the following conditions existing simultaneously:

- Any altitude, within the specified operating range up to 5000 ft. (1500m) elevation
- Any ambient temperature, within the specified operating range of 32°F to 104°F (0°C to 40°C)
- Any one failed fan
- Any input voltage within the specified range, +10% to -15% of nominal
- Air filters 50% blocked per the criteria included in UL1778

1.3.4 AC Input

1. Overload Capacity

   With nominal input voltage and without the battery connected, the rectifier shall be capable of supplying the inverter with the power needed to operate over the full inverter overload range.

2. Rectifier Voltage Range

   +10%, -30% of nominal (no battery charging below -15%)

3. Rectifier Frequency Range

   ±5Hz

4. Rectifier Walk-In

   0% to 100% of full rated load over 1-30 seconds (adjustable)

5. Rectifier Subcycle Magnetizing Inrush

   Not to exceed eight times normal full load input current

6. Rectifier Power Factor

   Minimum 0.90 lagging at full load with nominal input voltage

7. Two-Step Rectifier Input Current Limit:

   Step 1 - Independently adjustable 25-150% of normal full load input current

   Step 2 - Independently adjustable 25-150% for on-generator operation

8. Two-Step Battery Charge Current Limit:

   Step 1 - Independently adjustable 0-20% of maximum battery discharge current

   Step 2 - Independently adjustable 0-20% of maximum battery discharge current

9. Rectifier Current Distortion

   Less than 5% THD at full load input current (nominal input voltage)

10. Bypass Voltage Range

    +15%, -20%

11. Bypass Frequency Range

    ±5Hz

12. Rectifier and Bypass Surge Protection

    Sustains input surges without damage per criteria listed in ANSI C62.41, category B3 (6kV)

13. Withstand Rating

    Units shall carry a (65kA at 480V) (35kA at 600V) standard short circuit withstand rating, (100kA at 480V) (65kA at 600V) rating shall be available as options. All withstand ratings shall be UL tested and certified and a label applied to the unit clearly identifying this rating as required by the National Electric Code.

1.3.5 AC Output

1. Load Rating

   100% continuous load rating at 104°F (40°C) for any combination of linear and non-linear loads

2. Voltage Regulation

   ±1% for balanced load, ±2% for 50% unbalanced load for both line-to-line and line-to-neutral unbalances

3. Voltage Adjustment Range

   ±5% manually

4. Line Drop Compensation

   Adjustable 0 to +5% of nominal voltage

5. Frequency Regulation

   0.1%

6. Efficiency

   Defined as output kW/input kW at rated lagging load power factor. Greater than 97% in high-efficiency mode and 91.6% in double conversion mode from 50 to 100% load.

7. Phase Imbalance:

   - Balanced loads: 120° ±0.5°
   - Unbalanced loads: 120° ±1°

8. Voltage Transients (Average of All Three Phases):

   - 100% load step: ±5%
   - Loss of/return to AC input power: ±1%

9. Output Voltage Transients

   Voltage transients shall be limited to a maximum deviation from nominal system output volts of plus or minus 5% (RMS average for one cycle), with recovery to within 1.5% of nominal output voltage at the fifth cycle and beyond after transient for each of the following conditions. Limits shall apply to any UPS load within the UPS rating, and frequency shall be maintained at 60 Hz ±0.1 Hz. The system shall not transfer to bypass under these conditions (except Item c).

   a. 0 - 100 - 0% load step

   b. Loss or return of AC input power, or momentary sags, surges or spikes on the input to the UPS (all three phases or single phase)

   c. Uninterrupted transfer of the critical load to and from the UPS output and bypass power line (manually initiated or automatic)

   d. Dropping one MMU off the UPS output power bus by manual switching.

   e. Connecting one MMU onto the UPS output bus.

   f. Dropping one MMU off the UPS output power bus by internal failure.

10. Voltage Harmonic Distortion:

    - Maximum 2% RMS total (linear load)
    - Maximum 2.5% RMS total for up to 100% non-linear load, per IEC 62040-3

11. Overload at Full Output Voltage with ±1% Voltage Regulation:

    The overload rating of the UPS shall be the rating that can be demonstrated after operating at full load continuously at maximum operating temperature with a fan failed.

    - 104% continuously
    - 110% of full load for 60 minutes
    - 125% of full load for 10 minutes
    - 150% of full load for a minimum of 60 seconds

12. Current Limit

    Up to 200% of full load current

13. Fault Clearing

    - **Inverter Only:** 200% of normal full load current for 200 milliseconds, or 155% of normal full load current for 5 seconds (including a bolted fault condition when bypass is not available).
    - **Bypass Available:** 1000% for 200 milliseconds in inverter pulse-parallel operation when bypass is available for more rapid fault clearance downstream of the UPS.

14. Energizing a Transformer

    - **Inverter only:** Energize a transformer of the same kVA rating as the UPS without the inverter shutting down.
    - **Bypass available:** Energize a transformer of the same kVA rating as the UPS without the inverter shutting down and without transferring to bypass.
    - **Bypass available with full rated load:** Energize a transformer rated 20% kVA of the system rating without the inverter shutting down and without transferring to bypass.

1.3.6 Grounding

The AC output neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall have an equipment ground terminal. A terminal for bonding the system neutral to the facility service entrance ground (customer-supplied cable) shall be provided.

1.4 Environmental Conditions

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

1. Operating Ambient Temperature
   - **UPS:** 32°F to 104°F (0°C to 40°C) without derating

     (Consult factory for performance derating over 104°F [40°C])
   - **Battery:** 77°F (25°C), ±5°F (±3°C)
2. Storage/Transport Ambient Temperature

   -4°F to 158°F (-20°C to 70°C)
3. Relative Humidity

   0 to 95%, non-condensing
4. Altitude
   - **Operating:** To 5000 ft. (1500m) above Mean Sea Level without derating

     Consult factory for derating above 5000 ft. (1500m) elevation.
   - **Storage/Transport:** To 50,000 ft. (15,000m) above Mean Sea Level

1.5 Submittals

1.5.1 Proposal Submittals

Submittals with the proposal shall include:

- Descriptions of equipment to be furnished, including deviations from these specifications
- Document stating compliance with FCC requirements
- Document stating listing to UL, including edition used for listing
- Document showing compliance with required short circuit withstand rating and labeling
- System configuration with single-line diagrams
- Detailed layouts of customer power and control connections
- Functional relationship of equipment, including weights, dimensions and heat dissipation
- Information to allow distribution system coordination, including any overcurrent device in the bypass, and the manufacturer's part number or trip curve
- Size and weight of shipping units to be handled by contractor

1.5.2 Order Submittals

Submittals produced for the order shall include:

- All of the documentation presented with the proposal, per Section 1.5.1 above.
- Detailed installation drawings including all terminal locations.
- Interconnect wiring diagrams showing terminal numbers for each wire.

1.5.3 UPS Delivery Documents

Submittals upon UPS delivery shall include:

- A complete set of submittal drawings
- Two (2) sets of installation manuals; manuals shall include receiving and handling instructions.
- Two (2) sets of instruction manuals; manuals shall include a functional description of the equipment, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

1.6 Warranty

1.6.1 UPS Warranty

The UPS manufacturer shall warrant the unit against defects in workmanship and materials for 12 months after initial startup or 18 months after the shipping date, whichever comes first.

1.6.2 Warranty - End User

Warranties associated with items not manufactured by the UPS supplier, but included as part of the system, such as switchgear and batteries, shall be passed through to the end user.

1.7 Quality Assurance

1.7.1 Manufacturer's Qualifications

The manufacturer shall have a minimum of 20 years experience in the design, manufacture and testing of solid-state UPS systems.

The quality system for the engineering and manufacturing facility shall be certified to conform to Quality System Standard ISO 9001 for the design and manufacture of power protection systems for computers and other sensitive electronics.

1.7.2 Factory Testing

- Before shipment, the manufacturer shall test the UPS fully and completely to ensure compliance with the specification.
- The UPS shall be tested at the system-specified capacity. Testing shall be done using load banks at both part-load and the full kW rating of the unit and the system.
- Operational discharge and recharge tests shall be performed to ensure guaranteed rated performance.
- System operations such as startup, shutdown and transfers shall be demonstrated.
- A certified copy of test results shall be available for each system as indicated on the order.

2.0 PRODUCT

2.1 Fabrication

2.1.1 Materials

All materials of the UPS shall be new, of current manufacture and high-grade. They shall not have been in prior service except as required during factory testing. All active electronic devices shall be solid-state. All power semiconductors shall be sealed. Control logic and fuses shall be physically isolated from power train components to ensure operator safety and protection from heat. All electronic components shall be accessible from the front without removing subassemblies for service access.

2.1.2 Capacitor Assemblies

All power, AC and DC filter capacitors shall be mounted allowing field replacement of the capacitors separately from power switching controls and components.

2.1.3 UPS Internal Wiring

Internal power wiring shall be extra flexible terminated with compression type lugs. Lugs shall be attached with a hardware method that ensures long-life integrity. All factory-installed electrical power connections shall be torqued to the required value and marked with a visual indicator. All power connections not serviceable from the front of the unit shall be permanent, without any need for periodic tightening.

2.1.4 Field Wiring

Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards. All bolted connections of busbars, lugs and cables shall be in accordance with requirements of the National Electric Code and other applicable standards.

All field wiring power connections shall be to tin-plated copper busbars for connection integrity. Busbars shall have adequate space to allow two-hole, long-barrel, compression-type lugs forming a permanent connection between field wiring and field-installed lugs.

Provisions shall be made in the cabinets to permit installation of input, output and external control cabling, using raceway or conduit. Provision shall be made for top and bottom access to input, output, bypass and DC connections. In conformance with NEC, connection cabinets shall provide for adequate wire bend radius.

2.1.5 Construction and Mounting

The UPS shall be in a NEMA Type 1 enclosure, designed for floor mounting. The UPS shall be structurally adequate and have provisions for hoisting, jacking and forklift handling. Maximum cabinet height shall be 76.8 in. (1950mm).

The UPS shall be NEMA Type 1-compliant, with front doors open to enable safe change of air filters without the need for shutdown.

2.1.6 Cooling

Adequate ventilation shall be provided to ensure that all components are operated well within temperature ratings. The cabinet blowers shall be redundant so that a single blower failure will not cause temperatures to increase beyond acceptable continuous operation limits. Each blower shall be individually monitored for proper operation.

Temperature sensors shall be provided to monitor UPS internal temperature. Upon detection of temperatures in excess of the manufacturer's recommendations, the sensors shall initiate audible and visual alarms on the UPS control panel. A sensor for room ambient temperature shall be provided to give an alarm if the temperature of the inlet air to the UPS is above specified limits. Air filters shall be located at the point of air inlet and be replaceable. No service clearance or ventilation shall be required in the rear of the system.

2.1.7 Long Life Components

The UPS shall incorporate long life components to streamline maintenance, maximize uptime and minimize total cost of ownership.

2.2 Equipment

2.2.1 UPS System

The UPS system shall consist of the appropriate number of multi-module units for capacity or redundancy, system controls and system level bypass static switch (SCC), battery disconnect breaker(s) and battery system(s).

1. Each multi-module unit shall consist of a rectifier/charger and three-phase inverter with associated transformers.
2. The system control cabinet shall contain the bypass static transfer switch, the system-level monitoring and controls and bypass synchronizing circuitry.

2.2.2 Configurations Central Bypass Multi-Module

The UPS system shall consist of one or more multi-module unit (MMU) of the same kVA and kW rating operating in parallel. All MMUs shall operate simultaneously and share the load. The system shall be redundant or non-redundant as stated elsewhere in this specification.

In a non-redundant system, all the modules making up the UPS system shall supply the full rated load. If a module should malfunction, placing an overload on the remaining on-line modules, the load shall be transferred automatically and without interruption to the bypass line by the use of the system level bypass static switch.

For redundant operation, the UPS system shall have one or more modules than required to supply the full rated load. The malfunction of a module shall cause that module to be disconnected from the critical load by its output circuit breaker, and the remaining module(s) shall continue to carry the load. Upon repair of the malfunctioning module, it shall be reconnected to the critical load to resume redundant operation.

Any module shall also be capable of being isolated from the critical load manually for maintenance without disturbing the critical load bus. With one or more modules off-line, a malfunction of another module shall cause the load to be transferred automatically and without interruption to the bypass line by the use of the system level bypass static switch, if the load exceeds the capacity of the modules remaining on-line.

2.2.3 System Efficiency

The UPS system shall be provided with a high-efficiency mode of operation to increase the system efficiency when the bypass source is within voltage and frequency tolerance of the load. When the bypass power quality goes outside of the adjusted limits, the inverter shall assume the load in a seamless fashion without any interruption. During operation in high-efficiency mode the rectifier in each module shall continuously charge the battery and the inverter shall demonstrate synchronism with the bypass and current delivery by circulating current through the output filter. Isolating the inverter from the load by mechanical or solid state means shall not be allowed.

2.2.4 System Protection

1. **Surge Protection**

   The UPS shall have built-in protection against surges, sags and overvoltage from the AC source. The protection shall meet the requirements of ANSI C62.41 B3 including:

   - 6kV, 100kHZ ring wave, line-to-line, line-to-neutral, line-to-ground and neutral-to-ground
   - 6kV, combined wave, line-to-line, line-to-neutral, line-to-ground and neutral-to-ground

2. **Output Protection**

   The UPS shall be protected against sudden changes in output load and overload at the output terminals. The UPS shall have built-in protection against permanent damage to itself and the connected load for all predictable types of malfunctions. Fast-acting current-limiting devices shall be used to protect against cascading failure of solid-state devices. Internal UPS malfunctions shall cause the module to trip off-line with minimum damage to the module and provide maximum information to maintenance personnel regarding the reason for tripping off-line. The load shall be automatically transferred to the bypass line without any interruption for an internal UPS malfunction. The status of protective devices shall be indicated on a graphic display screen on the front of the unit.

3. **Containment During Fault Conditions**

   The UPS shall be designed for and demonstrate, as a part of testing for the short circuit withstand rating, adequate bracing of energized internal components. Testing shall include a three-phase short circuit at the input to the rectifier solid state switching devices and separately on the UPS output terminals. For the rectifier, the short circuit shall expose the customer input terminals, any interconnecting conductors and magnetic elements to the current, due to a fault on the line side of the input isolation transformer. A short circuit of the UPS output terminals shall expose the bypass input terminals, backfeed isolation device; bypass static switch and interconnecting conductors to the fault current. Testing shall demonstrate that the short circuit fault current will not cause a ground fault or internal arcing. Equipment compliance shall not require a specific manufacturer model or type of overcurrent device be supplied by the user.

2.3 Components

2.3.1 Rectifier/Charger

The term *rectifier/charger* shall denote a 12-pulse solid-state bridge with equipment and controls necessary to convert alternating current to regulated direct current for input to the inverter and for charging the battery.

The rectifier shall have a three-winding transformer providing full galvanic isolation between the utility power and the DC-Bus/Battery.

1. **Input Current Harmonic Distortion**

   Input current THD shall be less than 5% at full rated output load with nominal input voltage.

2. **AC Input Current Limiting**

   The rectifier/charger shall include a circuit to limit AC input current to an adjustable level of 25% to 150% of the full input current rating. A second circuit shall provide an additional selection (25% to 150%) when signaled by an external contact (e.g., operation of generator). AC input current limit shall be factory-set at 150% for normal operation and 100% for generator operation.

3. **Battery Charge Current Limiting**

   The rectifier/charger shall include a circuit to limit battery charging current to an adjustable level of 0% to 20% of maximum battery discharge current. A second circuit shall provide an additional selection (0% to 20%) when signaled by an external contact (e.g., operation of generator). Battery charge current limit shall be factory-set at 10% for normal operation and 0% for generator operation.

4. **Input Current Walk-In**

   The rectifier/charger shall provide a feature that limits the total initial power requirement at the input terminals to 0% of rated load and gradually increases power to 100% of full rating over the 30-second (adjustable) interval.

5. **Input Circuit Breaker**

   The rectifier/charger shall have an input circuit breaker. The circuit breaker shall be of the frame size and trip rating to supply full rated load and recharge the battery at the same time. The circuit breaker shall have an undervoltage release to open automatically and isolate all input power components if the control voltage is lost or if Emergency Power Off is signaled. The input circuit breaker interrupting capacity shall be equal to or greater than the UPS withstand rating. Switching devices with a lower rating are not acceptable.

6. **Rectifier Fuse Protection**

   Each rectifier AC phase shall be individually fused with fast-acting fuses so that loss of any semiconductor shall not cause cascading failures. Fuses shall be bolted to busbars at both ends to ensure mechanical and electrical integrity. The display panel on the front of the unit shall indicate a blown fuse occurring on any phase of the rectifier.

7. **DC Filter**

   The rectifier/charger shall have an output filter to minimize ripple current into the battery. The AC ripple voltage of the rectifier DC output shall not exceed 1% RMS of the float voltage. The filter shall be adequate to ensure that the DC output of the rectifier/charger will meet the input requirements of the inverter without the battery connected. The DC filter shall be fused independently from the rectifier fuses. DC filter fuse failure shall result in an orderly shutdown of the rectifier and inverter.

8. **Battery Recharge**

   In addition to supplying full power for the load, the rectifier/charger shall be capable of supplying a minimum of 5% of the module full load power rating for recharging the battery provided that the battery can accept recharge at that rate. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.

9. **Battery Equalize Charge**

   A manually initiated equalize charge feature shall be provided to apply an equalize voltage to the battery. The duration of equalize charge time shall be adjustable from 0 to 200 hours. A method shall be available to deactivate this feature for valve regulated battery systems.

10. **Stop Battery Charging Function**

    Battery charging may be stopped by an external signal that is activated by a contact closure to indicate a condition (including battery overtemperature, presence of excessive hydrogen or failure of room ventilator fan) under which battery charging is undesirable or inadvisable.

11. **Overvoltage Protection**

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

12. **Temperature-Compensated Charging**

    The UPS shall adjust the battery charging voltage based on the battery temperature reported from external battery temperature sensors. One temperature sensor shall be supplied for each battery string. Temperature sensors shall be monitored for faulty measurements and ignored if a fault is detected to prevent overcharging or undercharging the battery. When multiple sensors are used, the voltage shall be based on the average temperature measured. Excessive difference in the temperature measurements shall be reported and the charging voltage adjusted to protect the batteries from excessive current.

13. **Battery Load Testing**

    The UPS shall be capable of performing battery load testing under operator supervision. To accomplish this, the rectifier/charger shall reduce charging voltage to force the batteries to carry the load for a short time. If the curve of battery voltage drop indicates diminished battery capacity, the UPS shall display an alarm message. If the voltage drop indicates battery failure, the UPS shall terminate the test immediately and annunciate or display the appropriate alarms.

2.3.2 Inverter

The term *inverter* shall denote the equipment and controls to convert DC current from the rectifier/charger or battery to precise AC current to power the load. The inverter shall be solid-state and capable of providing rated output power. For increased performance, the inverter shall be a pulse-width-modulated design and utilize insulated gate bipolar transistors (IGBTs). The inverter shall be fully self-protected from load changes and an output short circuit. To further enhance reliable performance and efficiency, the inverter shall not require an inverter output series static switch/isolator for the purposes of overload or fault isolation or transfers to bypass. The output circuit breaker interrupting capacity shall be equal to or greater than the UPS short circuit withstand rating. Switching devices with a lower rating are not acceptable.

1. **Overload Capability**

   The inverter shall be able to sustain an overload across its output terminals up to 150% with ±2% output voltage regulation. The inverter shall be capable of at least 200% current for short circuit conditions including phase-to-phase, phase-to-ground and three-phase faults. If the short circuit is sustained, the load shall be transferred to the bypass source and the inverter shall disconnect automatically from the critical load bus.

2. **Output Frequency**

   The inverter shall track the bypass continuously, provided that the bypass source maintains a frequency of 60Hz ±0.1Hz. The inverter shall change its frequency (slew rate) at 0.1Hz per second (adjustable 0.1 to 3.0Hz per second) to maintain synchronous operation with the bypass. This shall allow make-before-break manual or automatic transfers. If the bypass fails to maintain proper frequency, the inverter shall revert to an internal oscillator, which shall be temperature-compensated and shall hold the inverter output frequency to 0.1% from the rated frequency for steady-state and transient conditions. Drift shall not exceed 0.1% during any 24-hour period. Total frequency deviation, including short-term fluctuations and drift, shall not exceed 0.1% from the rated frequency.

3. **Phase-to-Phase Balance**

   The inverter shall provide a phase-to-phase voltage displacement of no worse than ±1% with a 50% unbalanced load and up to 125% of the system output rating.

4. **Fault Sensing and Isolation**

   Fault sensing shall be provided to isolate a malfunctioning inverter from the critical load bus to prevent disturbance of the critical load voltage beyond the specified limits. The inverter shall monitor the load current for distribution system faults. When a fault occurs, the inverter shall go into protection mode, preventing any damage to the inverter.

5. **Output Circuit Breaker**

   The inverter shall be provided with a molded-case circuit breaker to isolate the inverter from the critical load bus. This circuit breaker shall be of the correct frame size and trip rating to supply full rated load and overload current as specified elsewhere in this document. The circuit breaker shall have an undervoltage release to open automatically and isolate all output power components if the control voltage is lost or if Emergency Power Off is signaled.

6. **Battery Protection**

   The inverter shall be provided with monitoring and control circuits to protect the battery system from damage due to excessive discharge. Inverter shutdown shall be initiated when the battery voltage has reached the end-of-discharge voltage. The battery end-of-discharge voltage shall be calculated and automatically adjusted for partial load conditions to allow extended operation without damaging the battery. Automatic shutdown based on discharge time shall not be acceptable.

2.3.3 Power Conversion Bypass

When maintenance is required or when the inverter cannot maintain voltage to the load due to inadequate DC power, sustained overload or malfunction, a bypass circuit shall be provided to isolate the inverter output from the load and provide a path for power directly from an alternate AC (bypass) source. The UPS control system shall constantly monitor the availability of the inverter bypass circuit to perform a transfer. The inverter bypass circuit shall consist of a continuous-duty bypass static switch and a circuit breaker to isolate the bypass static switch from the bypass source. The bypass static switch shall be a solid-state device consisting of two reverse-paralleled SCRs (silicon-controlled rectifiers) per phase that can automatically and instantaneously connect the alternate AC source to the load or isolate the load from the bypass source. The bypass circuit shall not include fuses in the path for the load. Fuses may prevent proper load circuit breaker tripping coordination.

1. **Manual Load Transfers**

   A manual load transfer between the inverter output and the alternate AC source shall be initiated from the control panel. Manually initiated transfers shall be make-before-break, utilizing the inverter and the static bypass switch.

2. **Automatic Load Transfers**

   An automatic load transfer between the inverter output and the alternate AC source shall be initiated if an overload condition is sustained for a time in excess of the inverter output capability or due to a malfunction that would affect the output voltage. Transfers caused by overloads only shall initiate an automatic retransfer of the load to the inverter only after the load has returned to a level within the rating of the inverter source. The UPS system logic shall allow up to five retransfers (adjustable) within any one-hour period to prevent cyclical transfers caused by overloads.

3. **Momentary Overloads**

   In the event of a load current inrush, such as energizing a load with high inrush current or branch load circuit fault in excess of the inverter's total rating, the bypass static switch shall connect the alternate AC source to the load for at least 200 milliseconds, allowing up to 1000% of the normal rated output current to flow. Output voltage shall be sustained to the extent the alternate AC source capacity permits. If the overload condition is removed before the end of the 200 milliseconds, the bypass static switch shall turn off and the load shall remain on inverter power. If the overload remains, then a transfer to the alternate AC source shall be completed.

4. **Backfeed Protection**

   As required by UL 1778 and CSA, the static bypass transfer switch shall not backfeed UPS power to the bypass input terminals and, therefore, to the distribution system while the UPS is operating on battery during a bypass power outage. The purpose of this requirement is to prevent the risk of electrical shock on the distribution system when the normal source of power is disconnected or has failed. If a shorted SCR is detected, the static transfer switch shall be isolated by an internal automatic circuit breaker and an alarm message shall be annunciated at the UPS control panel. The load shall remain on conditioned and protected power after detection of a shorted SCR and isolation of the static bypass switch. A device that cycles due to loss of utility and is, therefore, at a higher risk of failure than a device that normally remains closed is not acceptable. The backfeed prevention circuit breaker interrupting capacity shall be equal to or greater than the UPS withstand rating. Switching devices with a lower rating or series-rated devices are not acceptable.

5. **(Optional) Active Inverter Eco-Mode Operation**

   Economy operation shall be provided and shall be selectable by the user.

   When selected, this mode of operation shall transfer the load to the bypass source and maintain it there as long as the bypass source frequency, slew rate and voltage are within the adjusted operating parameters. While in this mode, the inverter shall remain operating to demonstrate the ability to instantaneously assume the load without interrupting the output voltage. Should the bypass source go outside the adjusted limits, the bypass static switch shall turn Off, isolating the load from the bypass while the inverter assumes the full critical load. The load shall be transferred from the bypass source to the inverter without an interruption of the output voltage.

   Operating adjustments shall include:

   - Limit the frequency of transfer into Intelligent Eco-Mode caused by an out-of-tolerance bypass source.
   - Specify day of the week and time of day to enable or disable Intelligent Eco-Mode operation.
   - Enable and disable Intelligent Eco-Mode operation.

6. **(Optional) Intelligent Paralleling Operation**

   When selected, this mode of operation shall place units in standby mode based on the available capacity of the installed units, the current load and the number of redundant units selected. While in standby mode a unit shall continue to charge the battery to maintain full battery capacity and as required by the battery manufacturers' published operating instructions. Units in standby mode shall be returned to full operation to maintain balanced operating hours and confirm proper operation. In the case of a utility outage units in standby mode shall be returned to full operating mode to allow the full battery capacity of the system to be available during the outage. Upon the return of utility power, units shall be placed in standby based on operating hours.

2.3.4 Display and Controls

1. **UPS Control Panel**

   Each Multi-Module Unit and the System Bypass Control shall be provided with a microprocessor-based control panel for operator interface (also referred to as User Interface, or UI) to configure and monitor the UPS. The control panel shall be located on the front of the unit and shall be operated without opening the hinged front door. The display shall not be attached to the front door so the door can be easily removed for maintenance.

A backlit, menu-driven, full graphics, color touchscreen liquid crystal display shall be used to enter setpoints, and it shall display system information, metering information, a one-line diagram of the UPS and its ancillaries, active events, event history, startup instructions and transfer and shutdown screens. No mechanical push buttons shall be used.

All configuration and settings shall be password-protected, and an optional key lock shall be available to restrict display functions to permit monitoring only, preventing any unauthorized operation from the display.

2. Logic

UPS logic and control programming shall reside in a microprocessor-based control system with non-volatile flash memory. Rectifier, inverter and bypass control logic shall utilize high-speed digital signal processors (DSPs). CANbus shall be used to communicate between the logic and the UI as well as the options. Switches, contacts and relays shall be used only to signal the logic system as to the status of mechanical devices or to signal user control inputs. Customer external signals shall be isolated from the UPS logic by relays or optical isolation.

3. Metered Values

A microprocessor shall control the display and memory functions of the monitoring system. All three phases of three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accurate (±1%) representation of non-sinusoidal waveforms typical of computers and other sensitive loads. These parameters shall be displayed:

Module Level Metering

- Input voltage, line-to-line
- Input current
- Input frequency
- Battery voltage, each battery string
- Battery charging/discharging current
- Output voltage, line-to-line and line-to-neutral
- Output frequency
- Bypass input voltage, line-to-line
- Bypass input frequency
- Load current
- Load kVA, total and percentage of full load
- Load kW, total and percentage of full load
- Load power factor, per phase
- Total operating hours
- Battery temperature, each battery string
- Battery state of charge

System Bypass Control

- Bypass input voltage, line-to-line
- Bypass input frequency
- Output voltage, line-to-line and line-to-neutral
- Output frequency
- Load current
- Load kW
- Load kVA
- Load power factor, per phase
- Number of redundant modules on line

4. **Power Flow Indications**

   A power flow diagram shall graphically depict whether the load is being supplied from the inverter, bypass or battery and provide, on the same screen, the status of these components:

   ### Module Level Mimic

   - AC input circuit breaker
   - Battery circuit breaker, each breaker
   - Inverter output circuit breaker
   - Maintenance bypass cabinet breakers (when used)

   ### System Level Mimic

   - Module Status
   - Backfeed breaker
   - Bypass Breaker (SCC)
   - System Output (SCC)
   - Bypass Static Switch (SCC)
   - Module Output Breakers (optional)
   - Maintenance Bypass Cabinet Breakers (optional)

5. **Battery Status Indicator**

   A battery status indicator shall display DC alarm conditions, battery state of charge, the present battery voltage, total discharge time and battery time remaining during discharge. A graphical representation of the battery voltage during the discharge shall be displayed. The graphical representation shall remain in the monitoring system memory until the next discharge occurs and shall be available for review of the battery performance.

6. **Battery Cycle Monitor**

The UPS shall have a Battery Cycle Monitor (BCM) built into system firmware to document the cycle service of the battery. It shall collect and retain information on the last 132 events that involved discharging the UPS battery. Each battery discharge cycle shall be put into one of nine categories, depending on the duration of the event:

- 0-30 seconds discharge
- 31-90 seconds discharge
- 91-240 seconds discharge
- 4-15 minutes discharge
- 15-30 minutes discharge
- 30-60 minutes discharge
- 60-240 minutes discharge
- 4-8 hours discharge
- 8 hours and up discharge

The BCM shall collect and retain this information for each discharge cycle:

- System time and date
- Event number
- Duration of cycle
- Lowest kW
- Maximum kW
- kW carried by the batteries at the start of cycle
- Ampere hours
- Status of battery breakers at start and end of the cycle

In addition, the BCM shall retain summary information on the total number of events, the cumulative ampere hours and the total discharge time since a given date.

The BCM shall be capable of storing information for up to 132 discharge cycle events in its data buffer. When the buffer approaches its capacity, a warning message shall be broadcast. Once the buffer is filled, new data shall replace the old on a first-in, first-out basis as new cycles occur.

The UPS operator shall be able to select either the BCM Summary screen, one of nine time buckets or a list of all records in order of occurrence. The records displayed for each of the time buckets or for all records shall display detailed information for each of the cycles.

During a battery discharge event, the Summary screen shall change to show information about the current discharge cycle. The screen shall display Active Battery Discharge Time in place of Total Battery Discharge Time and substitute Active Battery Amp Hours with Total Battery Amp Hours.

The UPS shall allow this information to be collected remotely through the Remote Service Terminal application program.

7. **Events**

The control panel shall report the system-level events listed below. An audible alarm shall be activated when any of the following events occurs. All events shall be displayed in text form.

- Input Not Available
- Rectifier Fault
- Input Current Imbalance
- Input Phase Rotation Error
- Input Current Limit
- Input Filter Cycle Lock
- DC Link Ground Fault Alarm (positive)
- DC Link Ground Fault Alarm (negative)
- Bypass Not Available
- Bypass Frequency Error
- Backfeed Breaker Open
- Bypass Static Switch Unable
- Excessive Pulse Parallels
- Bypass Overload Phase A
- Bypass Overload Phase B
- Bypass Overload Phase C
- Bypass Static Switch Overload Exceeded
- Excessive Auto Retransfers
- Auto Retransfer Failed
- Transfer Failed - Shutdown
- Battery Discharging
- Battery Low Warning
- Battery Low Shutdown
- Battery Ground Fault
- Battery Temperature Imbalance
- Battery Overtemperature Warning
- Battery Overtemperature Limit
- Battery Capacity Low
- Battery Test Failed
- Module Battery Disconnect Open
- Battery CB “#” Open
- Main Control Fault
- Inverter Fault
- Inverter Overload Phase A
- Inverter Overload Phase B
- Inverter Overload Phase C
- Inverter Overload Exceeded
- Low Power Factor Warning
- Leading Power Factor
- Maximum Load Alarm Phase A
- Maximum Load Alarm Phase B
- Maximum Load Alarm Phase C
- Output Fault
- Redundant Fan Failure
- Multiple Fan Failure
- Inlet Air Overtemperature Warning
- Outlet Air Overtemperature Limit
- Equipment Overtemperature Warning
- Equipment Overtemperature Limit
- Equipment Temperature Sensor Fail
- Battery Sensor Fail
- Breaker Open Fail
- Breaker Close Fail
- Fuse Failure
- Power Supply Failure
- Controller Error
- Internal Communication Error
- Auto Restart Failed
- LBS Inhibited
- EMO Shutdown
- REPO Shutdown
- Controls Communication Fail
- Communication Fail

8. **Controls**

System-level control functions shall be:

- UPS/Bypass Transfer Command
- Startup Screen
- UPS/System Shutdown Commands
- Maximum Load Exceeded Setpoint Adjustment
- Manual Transfer - Bypass Voltage High and Low Limit Adjustments
- Inlet Air Temperature Warning Setpoint Adjustment
- Battery Test Setpoint Adjustment
- Low Battery Warning (Minutes) Setpoint Adjustment
- Battery Temperature Warning and Limit Adjustments
- Open Battery Disconnect
- Battery Cell Count Adjustment
- Battery Float Voltage Setpoint Adjustment
- Event Mask (Latch, Audible, Event Log) Screen
- System Settings (Time, Date, Language, LCD Brightness, Password, Audio Level) Adjustments
- Audio Silence Command
- Alarm Reset Command
- Input Contact Isolator Setup Screen (optional)
- Programmable Relay Setup Screen (optional)
- Emergency Module Off Push Button with Protective Cover (optional)

9. **Manual Procedures**

Startup

The Startup screen shall be user-interactive on the display panel in text and graphic form and provide a step-by-step guide for the user to bring the UPS module on-line. Push buttons are also provided to enable the battery breaker and the input trap.

Load Transfers

Two buttons (UPS, BYPASS) shall provide the means for the user to transfer the load to Bypass and back on UPS. A synchroscope shall be provided to display the phasing between Bypass and Output in graphical representation.

Shutdown

Two buttons (UPS, SYSTEM) shall provide the means for the user to shut down the inverter and transfer the load to bypass or shut down the entire system. Push buttons are also provided to trip the battery breaker and the input trap.

10. **(Optional) Emergency Module Off**

    A local Emergency Module Off push button with protective cover shall be provided. Pressing the Emergency Module Off push button shall:

    - Initiate an uninterrupted transfer of the load to bypass and
    - Cause the input, output and battery breakers to open, completely isolating the UPS (except bypass) from power.

    Provisions shall be available for a remote Emergency Power Off signal that shall either transfer the load to bypass or completely remove power from the critical bus (operator-selectable) when activated.

2.3.5 Self-Diagnostics

1. **History Log File**

   Three History Log files shall be provided to record multiple incidents to aid in system troubleshooting. Security to protect the files from accidental erasure shall be provided. Each History Log file shall contain all metering, events and status information in 128 frames. The control system shall maintain this information in discrete 2-millisecond frames. This shall provide status recall of a period of 256 milliseconds (128 frames). Each frame is represented by a re-creation of the one-line mimic (replay). The breaker status and power flow shall be re-created to display the condition of the UPS in each frame.

2. **Event Log File**

   The control system shall maintain a log of the event conditions that have occurred during system operation. System memory shall be capable of storing up to 2048 events. Each log shall contain the event name, event type (status, alarm, fault), event time/date stamp, event ID, parametric data associated with the event and a set/clear indicator.

3. **System Status File**

   The control system shall monitor and display the total operating hours of the UPS system.

2.3.6 Remote Monitoring Capability

1. **Network Communication**

   The UPS shall be equipped with provisions for remote communication. IP20 isolation, to avoid exposure to any energized part, shall be provided during installation and configuring of the communication card.

   Standard communication protocols shall be Vertiv Protocol, Remote Service Delivery Protocol and HTTP Web. Communication shall be compatibility with DCIM Vertiv™ Liebert® *Trellis*™ platform and Vertiv™ Liebert® Nform management software.

   Two of three optional protocols shall be supported with simultaneous communication - SNMP, BACnet IP, Vertiv™ Liebert® Modbus IP/485.

2.3.7 Optional Features

1. **System Efficiency**

   The UPS module shall be provided with a high-efficiency mode of operation to increase the module efficiency when the bypass source is within voltage and frequency tolerance of the load. When the bypass power quality goes outside the adjusted limits, the inverter shall assume the load in a seamless fashion without the output voltage being interrupted. During operation in high-efficiency mode the rectifier shall continuously charge the battery and the inverter shall demonstrate synchronism with the bypass and current delivery by circulating current through the output filter. Isolating the inverter from the load by mechanical or solid state means shall not be allowed.

2. **Load Bus Sync Interface**

   The Load Bus Sync Interface shall enable independent UPS systems to remain synchronized when operating on battery or on unsynchronized input sources.

3. **Remote Alarm Contacts**

   Two Remote Alarm Contact assemblies, rated at 30VDC, 1A, shall be provided, as an option, for customer signaling. Two sets of Form C contacts shall be provided for each of eight alarm signal channels per assembly. The activation for each alarm signal channel shall be customer-selected for up to four individual alarms or as a summary of all alarms.

4. **Customer Contact Inputs**

   Two Customer Contact Interface assemblies shall be provided, as an option, for the input and display of customer-supplied alarm points or to initiate pre-assigned UPS operations. Each assembly shall provide eight channels, with a 24VDC, 100mA signal to be triggered by an isolated, normally open contact. When an assembly is selected as a customer-named event, the customer may also assign a name of up to 16 characters and the following actions individually to each alarm:

   - Annunciate horn while alarm is present
   - Latch horn on and display alarm until manually reset
   - Include this alarm in the summary alarm
   - Freeze the history status file
   - Initiate external communication
   - Delay action from this signal for 0 to 99.9 seconds

   When an assembly is selected as a pre-assigned UPS operation, these actions shall be initiated:

   - Reduced Rectifier Input Current
   - Reduced Battery Charge Current
   - Stop Battery Charging (up to seven separate signals)
   - Inhibit Rectifier Restart
   - Inhibit Bypass Autorestart
   - Inhibit Inverter Autorestart
   - Input Trap Filter Disconnect
   - Suspend High-Efficiency Mode
   - Transfer from Inverter to Bypass
   - Transfer from Bypass to Inverter

5. **Remote Alarm Panel**

   The remote alarm panel shall have LED alarm lights. An audible alarm shall sound upon any alarm condition. The surface- or flush-mounted NEMA 1 enclosed panel shall indicate:

   - Load on UPS
   - Load on Bypass
   - Battery Discharging
   - Low Battery Warning
   - Overload Warning
   - Ambient Overtemp Warning
   - UPS Alarm Condition
   - New Alarm Condition (for a second UPS alarm condition)
   - Audible Alarm with Reset Push Button
   - Lamp Test/Reset Push Button

6. **Seismic Anchorage Kits**

   Seismic anchorage kits shall be provided with the UPS unit, and if included the (optional) Matching Battery Cabinet, for use in seismic restraint as required for IBC 2012 or OSHPD certification.

3.0 BATTERY PLANT

The UPS system shall be provided with a battery plant that shall comply with the specifications of:

- Matching Battery Power Pack,
- Flooded-Cell Battery System on rack, or
- Valve-Regulated, Sealed Cell Battery System on rack.

The battery shall be fully charged per the manufacturer's instructions during startup and shall demonstrate the specified operating time.

3.1 Matching Battery Power Pack

The battery power pack shall consist of sealed, valve-regulated batteries, circuit breaker for isolating the battery pack from the UPS and a control interface to the UPS module. The circuit breaker shall be sized to allow discharge at the maximum published rating of the battery. The interface to the UPS module shall provide status and thermal data to allow the UPS to regulate the charging voltage and inhibit the conditions associated with battery thermal runaway. If the temperature measurement in a battery cabinet indicates that thermal runaway is occurring, then the UPS controls shall isolate the cabinet from the charger by tripping the battery breaker in that cabinet while leaving other battery cabinets connected to allow UPS operation during a loss of power to the rectifier.

The battery cabinet shall be rated NEMA 1, matching the UPS style and design.

- **Battery Cabinets Connected Directly to the UPS**: The manufacturer shall provide all power and control parts necessary to interconnect the UPS and battery cabinets.
- **Battery Cabinets Separated from the UPS**: The manufacturer shall provide all power and control parts necessary to interconnect the battery cabinets. The installer shall provide all cabling necessary to interconnect the UPS and the battery cabinets.

Both overhead and under-floor site installed cabling shall be accommodated. Installing cabling shall not require removal of batteries or any other battery cabinet assemblies.

The battery system shall be sized to support a _____kW load for _____ minutes. The battery system shall provide 100% initial capacity upon delivery.

The battery shall be lead-calcium, sealed, valve-regulated type with a three (3) -year full warranty and a seven (7) -year pro rata warranty under full float operation. The battery design shall utilize absorbent glass mat (AGM) technology to immobilize the electrolyte.

3.1.1 Optional Battery System Monitor

The battery system shall be provided with an Vertiv™ Liebert® Alber® universal battery diagnostic system. The system shall provide predictive on-line test, analysis and remote monitoring.

The system shall include automatic monitoring, alarming, recording and displaying of these battery parameters.

- Individual jar voltage (high and low alarm).
- Individual jar DC resistance (high and low alarm) accomplished by applying a momentary load at user-defined intervals.
- Individual inter tier and disconnect switch resistance measurements (high alarm) performed at user-defined intervals.
- Total overall battery voltage per string (high and low alarm).
- Two ambient temperatures per string for temperature trending (high and low alarm).

- Real time system discharge logging of the overall voltage, individual jar voltage (low alarm), discharge current (high alarm), and temperatures.
- Ripple current per string.
- String current (high alarm).
- Optional float current per string (high and low alarm).

The system shall provide reports for evaluation of the battery condition. Reports shall include:

- Alarm condition reporting – tabular, fax or e-mail.
- Jar out-of-limits summary report – tabular.
- Individual jar voltages over time – graph or tabular.
- Individual jar resistance values over time – graph or tabular.
- Total battery voltage over time – graph or tabular.
- Ambient temperature over time – graph or tabular.
- Discharge report: total battery voltage decay vs. time – graph or tabular.
- Discharge report: jar voltage decay vs. time – graph or tabular.
- Discharge hit summary report – tabular.
- Discharge hit interval summary report – tabular.
- General summary report of battery and monitor status of all systems to the battery or string level based on user-set thresholds.
- Detail summary reports of battery and monitor status of all systems with a line graph trend of any parameter that violated a threshold.
- Executive report showing overall system health.

Data from universal battery diagnostic system shall viewed through an Ethernet port with one of the following protocols - SNMP, TCP/IP/Modbus, SMS or HTTP. An optional RS-485 port shall be available for Modbus communication.

3.2 Flooded-Cell Battery System on Rack

The battery shall be a lead-calcium stationary battery with a 20-year pro rata warranty under full float operation.

1. Ratings
   - Backup Time: ____ minutes.
   - Load kW: ____ kW.
   - Maximum Specific Gravity: ____.
   - Racks shall be ____-tier, certified for seismic zone ____.
2. Alloys

   Grids shall be manufactured of lead-calcium alloys to ensure long life and consistently low gassing rate over the entire service life; all internal wetted parts shall be of similar non-antimonial alloy to preclude interfacial corrosion at the bonded area.

3. Plates

   Both positive and negative plates shall be of the flat pasted plate design to ensure highly reliable electrical performance throughout the life of the battery. Positive plates shall be at least 0.16 in. (4mm) thick. Physical support of the positive plate group shall be via a suspension system that allows for normal plate expansion without stressing the jar or cover. The plates shall be of the "wrapped plate design," such as C&D XT Plus or Enersys DXC, for high cycle application.

4. Terminals

   All batteries larger than 1.5kW/cell (15-minute rate to 1.67 volts per cell) shall include copper inserted terminal posts allowing connector torque of 160 pound-inches and copper-to-copper interface with the intercell connector (except for flashing). Terminal posts shall be of sufficient strength to support normal inter-tier or inter-step cabling without additional bracing.

5. Container

   The cell cover shall be of a flame-retardant material with an oxygen index of at least 28; all jars must be transparent to allow visual inspection of the plates and sediment spaces. Cell covers shall include provision for sampling of the electrolyte below the tops of the plates.

6. Intercell Connections

   For each bolted connection, lead-plated copper connectors and corrosion-resistant bolts shall be provided; interconnecting hardware shall be sized to permit discharge at the maximum published rate while allowing no more than 30 mV of voltage drop between adjacent units at the one-minute rate to 1.75 volts per cell (VPC). Along with the necessary hardware, the supplier shall furnish NO-OX-ID grease to coat the contact area of all electrical connections.

7. Racks

   Racks shall have welded steel support frames and unitized rail construction to prevent long-term warping and resulting stresses on the cells and interconnections. All metallic rack components that directly contact the battery shall be insulated by removable covers.

8. Packaging

   Packaging must allow lifting straps to be inserted beneath the cells without moving, lifting or tilting the cells. Packaging shall ensure that plates are oriented perpendicular to the normal direction of travel during transportation.

9. Manufacturing Controls

   Each cell shall be clearly identified as to cell type, voltage and capacity, as well as manufacturing control group, for future quality assurance traceability. All cells in the battery shall be tested to ensure 100% system capacity. The equipment shall be designed and manufactured under a quality assurance program that is controlled and documented by written policies, procedures or instructions, and that shall be carried out throughout the performance of the work. The quality assurance program shall conform to the requirements of ANSI N45.2, MIL I-45208A and MIL-Q-9858.

3.2.1 Battery Disconnect Breaker for Battery System on Racks

Each battery string shall be supplied with a molded-case circuit breaker listed to UL 489, supplement SC, for applications greater than 250VDC. The trip rating of the breaker shall be sized to allow the battery to operate at full rated capacity at the five-minute discharge rate. This shall allow a partially loaded UPS to operate even if one or more battery strings are offline. The molded-case circuit breaker interrupting rating shall be greater than the battery string fault current capability. The molded-case circuit breaker trip unit shall have an instantaneous trip of 135% of the breaker trip rating to ensure that a partially charged battery has sufficient fault current to trip the breaker. For other trip values greater than 135%, UPS manufacturer shall provide, upon request, calculations demonstrating proper coordination between battery and breaker.

The battery breaker shall be in a separate NEMA 1 enclosure for all systems on racks. When the breaker is open, there shall be no battery voltage in the UPS enclosure. The UPS shall automatically be disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level or when signaled by other control functions. The UPS shall be provided with a push button to trip the breaker from the control panel.

3.2.2 Optional Battery System Monitor

The battery system shall be provided with an Alber® battery diagnostic system. The system shall provide predictive on-line test, analysis and remote monitoring.

The system shall include automatic monitoring, alarming, recording and displaying of these battery parameters:

- Individual cell voltage (high and low alarm)
- Individual cell DC resistance (high and low alarm) accomplished by applying a momentary load at user-defined intervals.
- Individual inter-tier and disconnect switch resistance measurements (high alarm) performed at user-defined intervals.
- Optional individual intercell resistance measurements performed at user defined intervals.
- Total overall battery voltage per string (high and low alarm).
- Ambient temperatures per string for temperature trending (high and low alarm), with ability to add up to 10 temperatures per string for temperature trending (optional).
- Real time system discharge logging of the overall voltage, individual cell voltage (low alarm), discharge current (high alarm), and temperatures.
- String current (high alarm).
- Optional float current per string (high and low alarm).

The system shall provide reports for evaluation of the battery condition. Reports shall include:

- Alarm condition reporting – tabular, fax or email.
- Cell out-of-limits summary report – tabular.
- Individual cell voltages over time – graph or tabular.
- Individual cell resistance values over time – graph or tabular.
- Total battery voltage over time – graph or tabular.
- Ambient temperature over time – graph or tabular.
- Discharge report: total battery voltage decay vs. time – graph or tabular.
- Discharge report: cell voltage decay vs. time – graph or tabular.
- Discharge hit summary report – tabular.
- Discharge hit interval summary report – tabular.
- General summary report of battery and monitor status of all systems to the battery or string level based on user-set thresholds.
- Detail summary reports of battery and monitor status of all systems with a line graph trend of any parameter that violated a threshold.
- Executive report showing overall system health.

One RS-232 serial port shall be configurable for either a local PC to be connected at all times, for temporary viewing with a computer or permanently connected to a Building Management System. An optional RJ-45 Ethernet port shall be provided with one of the following protocols - SNMP, TCP/IP/Modbus.

3.3 Valve-Regulated, Sealed Cell Battery System on Rack

The battery shall be a lead-calcium, sealed, reduced-maintenance type with a one-year full warranty and a nine-year pro rata warranty under full float operation.

1. Ratings

   - Backup Time: ____ minutes
   - Load kW: ____kW
   - Racks shall be ____-tier, certified for seismic zone ____.

   Electrolyte Immobilization

   Battery shall utilize absorbent glass mat (AGM) technology to immobilize electrolyte.

2. Alloys

   Grids shall be manufactured of lead-calcium alloys to ensure long life and consistently low gassing rate over the entire service life; all internal wetted parts shall be of similar non-antimonial alloy to preclude interfacial corrosion at the bonded area.Plates

   Both positive and negative plates shall be of the flat pasted plate design to ensure highly reliable electrical performance throughout the life of the battery. Positive plates shall be equipped with fibrous retention mats to inhibit the loss of active material as a result of repeated cycling.

3. Terminals

   All batteries shall include copper inserted terminal posts allowing connector torque of 110 pound-inches and copper-to-copper interface with the intercell connector (except for flashing). Terminal posts shall be of sufficient strength to support normal inter-tier or inter-step cabling without additional bracing.

4. Container

   The cell container and cover shall be of a flame-retardant material with an oxygen index of at least 28. The cell cover shall include a low-pressure release vent. All cells larger than 25kW/cell (15 minute rate to 1.67 volts per cell) shall include an integral flash arrestor.

5. Intercell Connections

   For each bolted connection, tin-plated copper connectors and corrosion-resistant bolts shall be provided; interconnecting hardware shall be sized to permit discharge at the maximum published rate while allowing no more than 30 mV of voltage drop between adjacent units at the one-minute rate to 1.75 volts per cell (VPC). Along with the necessary hardware, the supplier shall furnish terminal connection coating compound if required by the battery manufacturer.

6. Manufacturing Controls

   Each cell shall be clearly identified as to cell type, voltage and capacity, as well as manufacturing control group, for future quality assurance traceability. All cells in the battery shall be tested to verify 100% system capacity. The equipment shall be designed and manufactured under a quality assurance program that is controlled and documented by written policies, procedures or instructions and that shall be carried out throughout the performance of the work. The quality assurance program shall conform to the requirements of ANSI N45.2, MIL-I-45208A and MIL-Q-9858.

3.3.1 Battery Disconnect Breaker for Battery System on Racks

Each battery string shall be supplied with a molded-case circuit breaker listed to UL 489, supplement SC, for applications greater than 250VDC. The trip rating of the breaker shall be sized to allow the battery to operate at full rated capacity at the five-minute discharge rate. This shall allow a partially loaded UPS to operate even if one or more battery strings are offline. The molded-case circuit breaker interrupting rating shall be greater than the battery string fault current capability. The molded-case circuit breaker trip unit shall have an instantaneous trip of 135% of the breaker trip rating to ensure that a partially charged battery has sufficient fault current to trip the breaker. For other trip values greater than 135%, UPS manufacturer shall provide, upon request, calculations demonstrating proper coordination between battery and breaker.

The battery breaker shall be in a separate NEMA 1 enclosure for all systems on racks. When the breaker is open, there shall be no battery voltage in the UPS enclosure. The UPS shall automatically be disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level or when signaled by other control functions. The UPS shall be provided with a push button to trip the breaker from the control panel.

3.3.2 Optional Battery System Monitor

The battery system shall be provided with an Vertiv™ Liebert® Alber™ universal battery diagnostic system. The system shall provide predictive on-line test, analysis and remote monitoring.

The system shall include automatic monitoring, alarming, recording and displaying of these battery parameters.

- Individual jar voltage (high and low alarm).
- Individual jar DC resistance (high and low alarm) accomplished by applying a momentary load at user-defined intervals.
- Individual inter-tier and disconnect switch resistance measurements (high alarm) performed at user-defined intervals.
- Total overall battery voltage per string (high and low alarm).
- Two ambient temperatures per string for temperature trending (high and low alarm).
- Real time system discharge logging of the overall voltage, individual jar voltage (low alarm), discharge current (high alarm), and temperatures.
- Ripple current per string.
- String current (high alarm).
- Optional float current per string (high and low alarm).

The system shall provide reports for evaluation of the battery condition. Reports shall include:

- Alarm condition reporting – tabular, fax or email.
- Jar out-of-limits summary report – tabular.
- Individual jar voltages over time – graph or tabular.
- Individual jar resistance values over time – graph or tabular.
- Total battery voltage over time – graph or tabular.
- Ambient temperature over time – graph or tabular.
- Discharge report: total battery voltage decay vs. time – graph or tabular.

- Discharge report: jar voltage decay vs. time – graph or tabular.
- Discharge hit summary report – tabular.
- Discharge hit interval summary report – tabular.
- General summary report of battery and monitor status of all systems to the battery or string level based on user-set thresholds.
- Detail summary reports of battery and monitor status of all systems with a line graph trend of any parameter that violated a threshold.
- Executive report showing overall system health.

Data from universal battery diagnostic system shall viewed through an Ethernet port with one of the following protocols - SNMP, TCP/IP/Modbus, SMS or HTTP. An optional RS-485 port shall be available for Modbus communication.

4.0 EXECUTION

4.1 Field Quality Control

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

Visual Inspection

1. Inspect equipment for signs of damage.
2. Verify installation per drawings supplied with installation manuals or submittal package.
3. Inspect cabinets for foreign objects.
4. Verify that neutral and ground conductors are properly sized and configured per the manufacturer's requirements as noted in the manufacturer's drawings supplied with installation manuals or submittal package.
5. Inspect electrolyte level in cells (flooded cells only).
6. Inspect all cell cases.
7. Inspect each cell for proper polarity.
8. Verify that all printed circuit boards are configured properly.

Mechanical Inspection

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

Electrical Inspection

1. Check all fuses for continuity.
2. Confirm input and bypass voltage and phase rotation are correct.
3. Verify control transformer connections are correct for voltages being used.
4. Verify connection and voltage of the battery string(s).

Unit Startup

1. Energize control power.
2. Perform control/logic checks and adjust to meet the manufacturer's specification.
3. Verify DC float and equalize voltage levels.
4. Verify DC voltage clamp and overvoltage shutdown levels.
5. Verify battery discharge, low battery warning and low battery shutdown levels.
6. Verify fuse monitor alarms and system shutdown.
7. Verify inverter voltages and regulation circuits.
8. Verify inverter/bypass sync circuits and set overlap time.
9. Perform manual transfers and returns.
    - Simulate utility outage at no load.
    - Verify proper recharge.

4.2 Manufacturer's Field Service

1. Service Personnel

The UPS manufacturer shall directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the startup and maintenance of UPS and power equipment.

The manufacturer shall provide a 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, on-site response time shall be four hours or less within 150 miles of a Vertiv Services center.

Two local customer engineers shall be assigned to the site with a regional office as a backup. Escalation procedures shall be in place to notify Power Technical Support if a site is not functioning within 24 hours.

2. Vertiv™ LIFE™ Services

The UPS manufacturer shall provide LIFE™ services, which provides 24x7 continuous monitoring of events and parametric data, event and data analysis reports, and dispatch of factory-trained field service personnel. The UPS shall be able to initiate periodic and critical event driven communication with a remote service center to transfer event and parametric data for analysis and action. The remote service center shall be staffed with factory-trained service personnel who are capable of receiving, analyzing and interpreting the communicated events and data. The remote service center personnel shall also be capable of dispatching factory-trained field service personnel to the location of the UPS.

3. Replacement Parts Stocking

Parts shall be available through an extensive network to ensure round-the-clock parts availability throughout the continental United States.

Spare parts shall be stocked by local field service personnel with backup available from regional parts centers and the manufacturing location. A national parts center Customer Support Parts Coordinator shall be on call 24 hours a day, 7 days a week, 365 days a year for immediate parts availability.

4. Maintenance Contracts

A complete offering of preventive and full-service maintenance contracts for both the UPS system and battery system shall be available.