

READ THIS FIRST

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

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

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY AND NOTES TO DESIGNER

- A. Section Includes:
 - 1. Three-phase, continuous duty, on-line, double-conversion, static-type, UPS units for sensitive electronic equipment loads with the following features:
 - a. Surge suppression.
 - b. Input harmonics reduction.
 - c. Rectifier-charger.
 - d. Inverter.
 - e. Static bypass transfer switch.
 - f. Battery and battery disconnect device.
 - g. Internal maintenance bypass/isolation switch.
 - h. Output isolation transformer.
 - i. Battery monitoring.
- B. Evaluate the need for a redundant incoming power source (normal or emergency) on a per project basis.
- C. Evaluate the need for an automatic transfer switch versus a manual transfer of the loads on a per project basis.
- D. The equipment supplier shall have a local service organization within 50 miles of the installation at STIA to support the equipment and provide training, parts and emergency maintenance and repairs.

- E. Designer shall select appropriate input/output voltages based on project parameters. Typical is 480V, 3P in/480V, 3P out.
- F. Specify UPS with minimum 30% spare load capacity for future growth.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. LCD: Liquid-crystal display.
- C. LED: Light-emitting diode.
- D. PC: Personal computer.
- E. THD: Total harmonic distortion.
- F. UPS: Uninterruptible power supply.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.
- B. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Manufacturer Certificates: For each product, from manufacturer.
- D. Factory Test Reports: Comply with specified requirements.
- E. Field quality-control reports.
- F. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.
- G. Warranties: Sample of special warranties.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Recommended spare parts shall be stocked by local field service organization with back up available from national parts center or manufacturing location.
1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 2. Cabinet Ventilation Filters: One complete set.
 3. One spare circuit board for each critical circuit.

1.9 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. UL Compliance: Listed and labeled under UL 1778 by an NRTL.

- D. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.
- E. Conform to ANSI C62.41 (IEEE 587), FCC Part 15, Class A and NEMA PE-1.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Transport using manufacturers provisions and per manufacturers recommendations.
- B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. Ship with accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

1.11 WARRANTY

- A. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
- B. UPS Warranties: Minimum 3 years from Final Acceptance on all parts and service, no sliding value based on time.
 - 1. Designer shall require that Manufacturer provide a toll free number for reaching a qualified person 24 hours/day, 7 days/week and 365 days/year.

PART 2 - PRODUCTS

2.1 DESIGN REQUIREMENTS

- A. The UPS unit shall consist of the following components:
 - 1. Input Autotransformer: Factory installed inside the UPS module cabinet. 208-208V and 480-208V UPS module input/output voltage configurations shall be served by the same transformer through tap selection.
 - 2. Rectifier/Charger with Input Filter.
 - 3. Battery.
 - 4. Inverter
 - 5. Static Bypass Transfer Switch
 - 6. Maintenance Bypass Switch
 - 7. Cooling
 - 8. Display and Control Module.
 - 9. The following items are optional:
 - a. Output Isolation Transformer
 - b. Output Distribution Section

- c. Remote Status and Alarm Panel
 - d. Communication Module in UPS for Remote Monitoring of Status, Parameter and Alarms
- B. Voltage:
- 1. Input: 480V OR 208V, 3-phase, 3 wire plus ground.
 - 2. Output: 480V OR 208V, 3-phase, 4 wire plus ground.
- C. Output Load Capacity: as indicated.
- D. UPS shall be rated for available fault current.

2.2 OPERATIONAL REQUIREMENTS

- A. Automatic operation includes the following:
- 1. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
 - 2. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
 - 3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
 - 4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
 - 5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
 - 6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
 - 7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
 - 8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
 - 9. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.
- B. Manual operation includes the following:
- 1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.

2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.
- C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:
1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
 2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.
- D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.
1. Ambient Temperature for Electronic Components: 32 to 104 deg F.
 2. Ambient Temperature for Battery: 20°C to 30°C.
 3. Relative Humidity: 0 to 95 percent, noncondensing.
 4. Altitude: Sea level to 1000 feet.

2.3 PERFORMANCE REQUIREMENTS

- A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:
1. Inverter is switched to battery source.
 2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
 3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
 4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
 5. Load is 50 percent unbalanced continuously.
- B. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is 90 minutes. Less than 90 minute duration requires F&I approval.

- C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 20 percent from nominal voltage.
- D. Maximum Energizing Inrush Current: 1.5 times the full-load current.
- E. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.
- F. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.
- G. Limitation of harmonic distortion of input current to the UPS shall be as follows:
 - 1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 2% for 100% linear load and 6% for 100% non-linear load.
- H. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 60 seconds in all operating modes.
- I. Output-Voltage Transient Response: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and will, within 50 ms recover to, and remain within, plus or minus 1 percent for 100% linear load and plus or minus 3 percent for 100% non-linear load.:
 - 1. 50 Percent: Plus or minus 5 percent.
 - 2. 100 Percent: Plus or minus 5 percent.
 - 3. Loss of AC Input Power: Plus or minus 1 percent.
 - 4. Restoration of AC Input Power: Plus or minus 1 percent.
- J. Input Power Factor: 0.99 minimum.
- K. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

2.4 UPS SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. EATON Corp
 - 2. Liebert Corporation.
 - 3. Mitsubishi
 - 4. Or approved equal

- B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- C. Enclosures: Freestanding NEMA 250, Type 1, unless otherwise indicated.
 - 1. Cabinet doors/covers shall require a tool for gaining access.
 - 2. Provide casters and leveling feet for ease of installation.
 - 3. Front access only shall be required for servicing, adjustments and installation.
- D. Control and Monitoring Assemblies: Mount on front of the UPS cabinet, readily accessible for maintenance.
- E. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.
 - 1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B.
- F. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
- G. Capacity Upgrade Capability: Selected systems shall be able to accept a field installed power upgrade to the next higher power rating without an increase in cabinet size.
- H. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.
- I. UPS Cabinet Ventilation and Cooling: Low velocity forced air redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear. Fan power shall be provided by the UPS output.
- J. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.5 RECTIFIER-CHARGER WITH INPUT FILTER

- A. General:
 - 1. IGBT pulse width modulation.
 - 2. Input current distortion shall be <5% at 100% load.
 - 3. Soft start shall be linear from 0-100% and shall not exhibit inrush. This shall take place over a 15 second time period.
 - 4. Converters housed within parallel connected, removable power modules.

5. Converter shall control and limit the input current draw from the utility to 150% of UPS output. During conditions where input current limit is active, the UPS shall be able to support 100% load, charge batteries and provide voltage regulation.
- B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
- C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
- D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
 1. Response Time: Field adjustable for maximum compatibility with local generator-set power source, where required.
- E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.6 INVERTER

- A. Description: IGBT Pulse-width modulated, with sinusoidal output with output voltage independent of the utility input voltage. Input voltage anomalies shall not affect amplitudes or sinusoidal nature of output voltage sine wave.
- B. There shall be redundant output inverters each with semiconductor for fusing and logic controlled contactors to remove a failed component from the critical bus.
- C. Overload Rating:
 1. Normal Operation: 150% for 60 seconds in normal operation, 125% for 10 minutes in normal operation, 150% for 60 seconds in battery operation.
 2. Bypass Operation: 110% continuous, 1000% for 100 milliseconds for short circuit clearing.

2.7 STATIC BYPASS TRANSFER SWITCH

- A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch. Shall consist of fully rated SCRs with a continuous duty rating of 125% of UPS output rating.
- B. Static bypass switch shall constantly monitor the auxiliary contacts of their respective circuit breakers as well as the bypass source voltage and inhibit potentially unsuccessful transfers to static bypass from taking place.

- C. An automatic transfer of load to static bypass shall take place whenever the load on the critical bus exceeds the overload rating of the UPS. Automatic transfers of the critical load from static bypass back to normal operations shall take place when the overload condition is removed from the critical bus output of the system.
- D. Automatic transfers of load shall take place if for any reason the UPS cannot support the critical bus.
- E. The bypass switch shall be modular in design.
- F. Provide back feed protection in the static bypass circuit via mechanical contactor in series with the SCRs.

2.8 BATTERY

- A. Description: Sealed, valve-regulated, recombinant, lead-acid units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
 - 1. UPS battery shall be of modular construction made up of user-replaceable, hot-swappable fused battery modules.
 - 2. Each battery module shall be monitored for voltage and temperature. The UPS shall incorporate a battery management system to continuously monitor the health of each removable battery module.
 - 3. Battery jars housed within each removable battery module shall be Valve Regulated Lead Acid (VRLA) type.
- B. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

2.9 CONTROLS AND INDICATIONS

- A. Description: The UPS shall be provided with a microprocessor based unit status/alarm display and controls section. Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
- B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays. A system power flow diagram shall be provided.
- C. The display unit shall allow the user to display a time and date stamped log of the most recent statuses and alarm events. Unit shall provide data on the year month day, hour, minute and second of occurring event.
- D. Indications: Labeled LED OR plain-language messages on a digital LCD or LED.
 - 1. Quantitative indications shall include the following:

- a. Input voltage, each phase, line to line.
- b. Input current, each phase, line to line.
- c. Bypass input voltage, each phase, line to line.
- d. Bypass input frequency.
- e. System output voltage, each phase, line to line.
- f. System output current, each phase.
- g. System output frequency.
- h. DC bus voltage.
- i. Battery voltage.
- j. Battery current and direction (charge/discharge).
- k. Elapsed time discharging battery.
2. Basic status condition indications shall include the following:
 - a. Normal operation.
 - b. Load-on bypass.
 - c. Load-on battery.
 - d. Inverter off.
 - e. Alarm condition.
3. Alarm Messages: Appropriate alarm messages shall be displayed and an audible alarm shall be provided and activated by the following alarm conditions:
 - a. Input frequency outside configured range.
 - b. AC adequate for UPS but not for bypass.
 - c. Low/no AC input.
 - d. Battery system alarm, including the following:
 - 1) Battery needs replacement.
 - 2) Bad battery module.
 - 3) Battery charging control faulty.
 - 4) Low battery warning.
 - 5) Low battery shutdown.
 - 6) Maximum battery voltage.
 - e. Bypass ac input overvoltage or undervoltage.
 - f. Bypass ac input overfrequency or underfrequency.
 - g. Bypass ac input and inverter out of synchronization.
 - h. Bypass ac input wrong-phase rotation.
 - i. Bypass ac input single-phase condition.
 - j. Bypass ac input filter fuse blown.
 - k. Internal frequency standard in use.
 - l. Control power failure.
 - m. Fan failure.
 - n. Load on battery.
 - o. UPS in bypass due to overload.
 - p. UPS in bypass due to internal fault.
 - q. Shutdown on unable to transfer to battery due to overload.
 - r. Load is above alarm threshold.
 - s. Runtime is below alarm threshold.
 - t. Redundancy has been lost.
 - u. Input overvoltage or undervoltage.
 - v. Input transformer overtemperature.
 - w. Input circuit breaker tripped.
 - x. Input wrong-phase rotation.

- y. Input single-phase condition.
- z. Inverter fuse blown.
- aa. Inverter transformer overtemperature.
- bb. Inverter overtemperature.
- cc. Static bypass transfer switch overtemperature.
- dd. Inverter power supply fault.
- ee. Inverter transistors out of saturation.
- ff. Identification of faulty inverter section/leg.
- gg. Inverter output overvoltage or undervoltage.
- hh. Inverter current sensor fault.
- ii. Inverter output contactor open.
- jj. Inverter current limit.
- 4. Controls shall include the following:
 - a. Inverter on-off.
 - b. UPS start.
 - c. Battery test.
 - d. Alarm silence/reset.
 - e. Output-voltage adjustment.
- E. Dry-form "C" contacts shall be available for remote indication of the following conditions:
 - 1. UPS in alarm condition.
- F. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.10 MAINTENANCE BYPASS/ISOLATION SWITCH

- A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to directly route the flow of input AC power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
 - 1. Switch shall electrically isolate other UPS components to permit safe servicing.
- B. Comply with NEMA PB 2 and UL 891 for floor mounted units.
- C. Switch Rating: Continuous duty at rated full UPS load current.
- D. Mounting Provisions: Internal to system cabinet.

2.11 BASIC BATTERY MONITORING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Albercorp.
 - 2. BTECH, Inc.
 - 3. Eaton Corporation.

- A. Performance: Automatically measures and electronically records the following parameters on a routine schedule and during battery discharge events. During discharge events, records measurements timed to nearest second; includes measurements of the following parameters:
1. Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
 2. Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
 3. Charge rate: Monitors charge rate and initiates alarm if charge rate deviates from normally acceptable range.
- B. Annunciation of Alarms: At UPS control panel.

2.12 OUTPUT ISOLATION TRANSFORMER

- A. Description: Shielded unit with low forward transfer impedance up to 3 kHz, minimum. Include the following features:
1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 4 OR 7 OR 13.
 2. Output Impedance at Fundamental Frequency: Between 3 and 5 percent.
 3. Regulation: 5 percent, maximum, at rated nonlinear load current.
 4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
 5. Electrostatic Shielding of Windings: Independent for each winding.
 6. Coil Leads: Physically arranged for minimum interlead capacitance.
 7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."

2.13 OUTPUT DISTRIBUTION SECTION

- A. Panelboards: Comply with Section 262416 "Panelboards" except provide assembly integral to UPS cabinet.

2.14 SOURCE QUALITY CONTROL

- A. Factory test complete UPS system before shipment. Use simulated battery testing. Include the following:
1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 2. Full-load test.
 3. Transient-load response test.
 4. Overload test.
 5. Power failure test.
- B. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - INSTALLATION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Delivery, Storage and Handling: Deliver equipment in fully enclosed vehicles and store equipment in spaces and environments controlled with manufacturer's ambient temperature and humidity tolerances.

3.2 EQUIPMENT INSTALLATION

- A. Equipment Mounting: Install UPS on 3-1/2" high concrete base. Concrete shall be rated for 3000 psi minimum.
 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

3.3 GROUNDING

- A. Separately Derived Systems: Comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.

- B. The AC output neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall have an equipment ground terminal.

3.4 IDENTIFICATION

- A. Identify components and wiring according to Section 260553 "Identification for Electrical Systems."
1. Identify each battery cell individually.

3.5 BATTERY EQUALIZATION

- A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.6 FIELD QUALITY CONTROL

- A. Perform visual inspections including inspection for signs of damage, verification that neutral and ground conductors are properly sized and configured, proper polarity for batteries, and presence of foreign objects in cabinets.
- B. Perform mechanical inspections for tightness and integrity of power and control wiring connections.
- C. Perform electrical inspections to include confirmation that input voltage and phase rotation is correct, fuse continuity checks and verify control transformers for proper voltages being used.
- D. For UPS systems above 20kVA, load the system using a variable load bank to simulate kVA, kW and PF of load for the unit's rating.
1. Simulate malfunctions to verify protective device operation.
 2. Test duration of supply on emergency, low-battery voltage shutdown and transfers and restoration due to normal source failure.
 3. Test output voltage under specified transient load conditions.
 4. Test efficiency at 50%, 75% and 100% rated loads.
 5. Test remote status and alarm functions.
 6. Test batter-monitoring system functions.
- E. Inspect type, size, quantity, arrangement and proper installation of mounting or anchorage devices.
- F. Testing Agency: Engage a qualified testing agency to perform the following tests and inspections. Schedule monitoring and testing activity with the Port with at least 10 days advance notice.
1. Comply with manufacturer's written instructions.

2. Monitor the following parameters as a minimum:
 - a. Current
 - b. Voltage
 - c. Frequency transients
 - d. Voltage swells and sags
 - e. High frequency noise.
 - f. RFI
 - g. Current and voltage THD.
 3. Utilize monitoring and testing instruments to provide continuous simultaneous monitoring of electrical parameters at input terminals of the UPS and at input terminals of two or more major loads served by the UPS. Simulate utility power failure and ensure proper system functioning.
 4. Provide an analysis of recorded data and a detailed written report, signed and dated.
- G. Installing Contractor shall perform the following testing assistance:
1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement as requested by the Independent Testing Agency.
 2. Observe monitoring and testing operations to ensure that UPS and distribution and load equipment warranties are not compromised.
 3. Perform switching and control of various UPS units, electrical distribution systems and load components as directed by Independent Testing Agency.
 4. Test communication of status and alarms to remote battery monitoring equipment.
- H. The UPS system will be considered defective if it does not pass tests and inspections.
- I. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
- J. Prepare test and inspection reports.

3.7 PERFORMANCE TESTING

- A. Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.
- B. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period.
 1. Schedule monitoring and testing activity with Port, through Architect, with at least 14 days' advance notice.
 2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.
- C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters

at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.

D. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

E. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

F. Final Reports: Provide an interim report at the final comprehensive report at the end of final test and analysis period.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.
 - 1. UPS manufacturer or supplier shall be able to provide local maintenance training courses for maintenance personnel. This training shall be in addition to the basic operator training conducted as part of system start up.
 - 2. Training courses shall cover UPS theory, location of subassemblies, safety, battery considerations and UPS operational procedures.

END OF SECTION 263353