

UNINTERRUPTIBLE POWER SYSTEMS STATIC

1. GENERAL

1.1 Description of System

- .1 System to consist of:
 - .1 Rectifier cubicle
 - .2 Inverter cubicle
 - .3 Battery cubicle
 - .4 Bypass switch cubicle
 - .5 Controls and meters
- .2 System to use normal power supply mains and battery to provide continuous, regulated AC power to isolated load.
- .3 Equipment to operate continuously and unattended.
- .4 Ensure that UPS is compatible with equipment that it feeds.

1.2 Shop Drawings

- .1 Submit shop drawings in accordance with Section 01300 – Submittals.
- .2 Include:
 - .1 Outline sketch showing arrangement of cubicles, meters, controls, recommended aisle spaces, battery rack, battery arrangement and dimensions.
 - .2 Shipping weight.
 - .3 Schematic diagram showing interconnection of rectifier, inverter, battery, bypass switch, meters, controls and indicating lamps.
 - .4 Description of system operation, referenced to schematic diagram, for:
 - .1 Manual control during initial start-up and load transfer to bypass and back to inverter output.
 - .2 Inverter.
 - .3 Bypass.
- .5 System performance and reliability:

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- .1 Consider any deviation from the required output power waveform as a failure in the UPS and include an estimate, with supporting calculations, of the Mean Time Between Failures (MTBF) expressed in hours.
- .2 Provide an estimate with supporting data for the Mean Time to Repair factor (MTTR).
- .6 Full load kVA output at 0.8 power factor.
- .7 Efficiency of system at 25%, 50%, 75% and 100% rated load.
- .8 Type of ventilation: natural or forced.
- .9 Battery:
 - .1 Number of cells.
 - .2 Maximum and minimum voltages.
 - .3 Type of battery.
 - .4 Type of plates.
 - .5 Catalogue data with cell trade name and type.
 - .6 Size and weight of each cell.
 - .7 Cell charge and discharge curves of voltage, current, time and capacity.
 - .8 Derating factor for specified temperature range.
 - .9 Nominal ampere hour capacity of each cell.
 - .10 Maximum short circuit current.
 - .11 Maximum charging current expected for fully discharged condition.
 - .12 Recommended low voltage limit for fully discharged condition.
 - .13 Expected life.
- .10 Inverter:
 - .1 Type and catalogue number.
 - .2 DC current at minimum battery voltage to produce full load AC output.

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- .11 Rectifier:
 - .1 Type and capacity, with catalogue number.
 - .2 Battery charging sequence.
 - .3 Current-time data for SCR protective devices.
 - .4 Guaranteed noise level.
 - .5 Estimated life.
 - .6 Metering.
 - .7 Alarms.
- .12 Manufacturer's field experience with uninterruptible power systems of similar ratings including engineering expertise, manufacturing facilities and listing of UPS units manufactured and installed during last five (5) years including model, customer, location and installation dates.
- .13 Heat losses at no load, 25%, 50%, 75%, and 100% of rated output, in kW.
- .14 Cooling air required in m³/s.
- .15 List of recommended spare parts, tools and instruments with catalogue numbers and current prices.
- .16 Typical O&M Manual.
- .17 Description of factory test facilities.
- .18 Manufacturer's maintenance capabilities including:
 - .1 Willingness to undertake maintenance contract.
 - .2 Number of trained personnel available.
 - .3 Location of trained personnel and repair facilities.

1.3 Operation and Maintenance Data

- .1 Provide data for incorporation into O&M Manual specified in Section 01300 – Submittals.
- .2 Submit interim copies to Contract Administrator prior to notification of factory test date.

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- .3 O&M Manual to include:
 - .1 O&M instructions concerning design elements, construction features, component functions and maintenance requirements to permit effective operations maintenance and repair.
 - .2 Technical data:
 - .1 Characteristic curves for automatic circuit breakers and protective devices.
 - .2 Project data.
 - .3 Technical description of components.
 - .4 Parts lists with names and addresses of suppliers.

1.4 Maintenance Materials

- .1 Provide maintenance materials in accordance with Division 1 – Maintenance Materials, Special tools and spare parts
- .2 Include:
 - .1 Four (4) sets of each type and size of fuses used.
 - .2 Four (4) sets indicating lamps.
 - .3 Spare parts provided.

1.5 Care, Operation, and Start-Up

- .1 Arrange with Contract Administrator:
 - .1 For Manufacturer's Rep to provide support start-up of system, checking, adjusting and testing on Site.
 - .2 For instruction of O&M personnel on theory, construction, installation, operation and maintenance of system:
 - .1 After installation and during Site testing.
 - .2 At factory during shop testing.
- .2 Advise on:
 - .1 Expected failure rate of equipment
 - .2 Type of expected failures

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- .3 Estimated time between major overhauls based on twenty (20) year equipment life.
- .4 Estimated cost of major overhaul based on current costs and excluding traveling expenses.
- .5 Type and cost of test equipment needed for fault isolating and performing preventive maintenance.

1.6 Delivery and Storage

- .1 Crating:
 - .1 Adequately enclosed and protected from weather and shipping damage by use of minimum 12 mm plywood with vapour barrier inside.
 - .2 For tractor train or sea shipment, use double layer of vapour barrier and 19 mm plywood covering.
 - .3 Subassemblies may be packed separately.
 - .4 Label crates:
 - .1 Shipping address.
 - .2 Weight and dimensions.
 - .3 Serial number of unit and brief description of contents.
 - .4 Stenciled with durable paint on at least two sides of each crate.
 - .5 List of contents:
 - .1 In weatherproof envelope stapled on outside of each crate.
 - .2 Copy placed inside each crate.

1.7 Source Quality Control

- .1 Complete system including rectifier, inverter, bypass switch, remote annunciator panel, controls and battery factory tested.
- .2 Tests:
 - .1 Visual inspection to determine that:
 - .1 Materials, workmanship, and assembly conform to design requirements.
 - .2 Parts are new and free of defects.

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- .3 Battery and components are not damaged.
- .4 Battery cells are of identical construction.
- .5 Electrolyte in each cell is at manufacturer's recommended full level.
- .6 Each battery cell polarity and polarity of connections to inverter is correct.
- .7 Proper size fuses are installed.
- .8 Meters have suitable range.
- .9 Accessories are present.

1.8 Extended Warranty

- .1 The Contractor hereby warrants the battery against defects in material and workmanship in accordance with GC: 13 and D25, but for ten (10) years. This warranty is for 100% replacement for the first year and prorated in equal yearly decreasing increments for the remaining nine (9) years until the expiration of the warranty at the end of ten (10) years from the date of Total Performance.

2. PRODUCTS

2.1 Uninterruptible Power System

- .1 Input power:
 - .1 3 phase, 208 V, 3 wire, grounded neutral, 60 Hz.
 - .2 Normal supply from AC mains.
 - .3 Emergency supply from standby automatic diesel-electric unit.
- .2 Output power:
 - .1 Three phase, 208 V, 4 wire, grounded neutral, 60 Hz.
 - .2 Full load output at 0.8 power factor lagging 10 kVA.
 - .3 Overload capability: 125% of rated full load current at 0.8 power factor and rated voltage for 10 minutes.
 - .4 Frequency - nominal 60 Hz:
 - .1 Adjustable from 58.5 to 61.5 Hz.

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- .2 Maximum variation from set value under load changes, including transients, not to exceed 0.3 Hz.
- .3 Drift from set value - after two months normal operation within ambient temperature range of 0° to 40°C, not to exceed 0.6 Hz.
- .5 Duration of full load output after mains failure not less than 15 minutes.
- .6 Output voltage control:
 - .1 Continuously adjustable on load at least 5% from rated value.
 - .2 Voltage regulation: voltage not to change by more than 2% as load increases gradually from zero to 100%, or for specified duration of full load after mains failure.
 - .3 Transient voltage change not to exceed +/-10% of rated voltage upon 50% sudden load change, loss or return of AC input voltage to system when fully loaded or transfer of full load from inverter to bypass and vice versa, and return to normal within 3 Hz.
 - .4 Harmonics over entire load range:
 - .1 Total rms value not to exceed 5% rms value of total output voltage.
 - .2 Single harmonic not to exceed 3% of total output voltage.
 - .5 Proper angular phase relation maintained within 4 electrical degrees at up to 20% load unbalance.
- .7 Efficiency: Overall system efficiency at rated load with battery fully charged not less than 75%.
- .8 Interference suppression:
 - .1 If UPS equipment generates electromagnetic rf interference at levels which adversely affects other equipment in vicinity, install suppression circuits or shielding as required to eliminate such interference.
 - .2 If harmonics reflected back to mains from rectifier adversely affect other loads connected to same bus, install suppression circuits to prevent that condition.

2.2 System Performance

- .1 Normal operation:
 - .1 System operates on mains power when mains voltage is within +/-10% of nominal value and mains frequency is between 59.5 and 60.5 Hz.

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- .2 Battery operation:
 - .1 System transfers automatically to battery operation.
 - .1 When manually selected at control panel.
 - .2 When mains power fails.
 - .3 When mains voltage varies more than 10% from nominal or mains frequency varies more than 0.5 Hz from 60 Hz.
 - .4 When mains power is restored and mains voltage is within 10% of nominal and mains frequency is within 0.3 Hz of 60 Hz, system automatically resynchronizes with mains.
 - .5 Slew rate of frequency during transition period of system output automatically synchronizing with mains and return to its internal frequency to be set between 0.5 to 1.0 Hz per second.
 - .3 Bypass operation:
 - .1 For maintenance purposes, system can be bypassed automatically by manual selection at control panel to connect load directly to AC mains. Transfer without load interruption and leaving inverter energized.
 - .2 Load transfer from mains back to system automatically by manual selection at control panel when maintenance completed.
 - .3 Automatic transfer of load to mains in not more than $\frac{1}{4}$ cycle including sensing with inverter left energized but disconnected from load in case of:
 - .1 Inverter overloaded.
 - .2 Short circuit in load.
 - .4 Automatic retransfer of load to system without load interruption when above conditions disappear.
 - .5 Automatic transfer of load to mains in not more than $\frac{1}{4}$ cycle including sensing and shutdown of inverter in case of inverter internal malfunctions.
 - .6 Automatic transfer of load to mains without load interruption and inverter shutdown in case of:
 - .1 Over-temperature harmful to system.
 - .2 Loss of forced ventilation.
 - .3 Low voltage of DC supply to inverter.

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- .7 Bypass capable of closing onto and withstanding momentary fault current of 800% of rating for 0.01 s.

2.3 System Protection

- .1 Circuit breakers in system used to isolate it from load and from mains for safe working on equipment, and for manual blocking of bypass automatic control to prevent inadvertent operation of bypass during work on inverter.
- .2 Automatic circuit breakers and protection included in:
 - .1 AC input to rectifier.
 - .2 Battery input.
 - .3 Bypass circuit input.
 - .4 Inverter output.
- .3 Surge suppressors:
 - .1 To protect system against supply voltage switching transients.
 - .2 To protect internal circuits where necessary against voltage transients.
- .4 Current limiting devices, with panel front indication of device operation, to protect inverter SCRs.
- .5 Suitable devices, with panel front indication of device operation, to protect rectifier diodes.
- .6 Failure of circuit or component not to cause equipment to operate in dangerous or uncontrolled mode.

2.4 Electrical Requirements

- .1 Bring out test points to protected coded pin jacks at convenient locations to permit testing without hazard, including:
 - .1 Inverter output ahead of output switch, 3 phase and neutral.
 - .2 Mains power 3 phase and neutral.
 - .3 Voltage across each SCR.
 - .4 Points requiring monitoring for on Site alignment, for determination of faulty sub-assemblies or printed circuit cards, including indication of oscillator pulse and operation of voltage control.

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- .2 No battery, other than main battery incorporated in design.
- .3 Wires number tagged or colour coded with same designation on drawings. Tags: non deteriorating type.
- .4 Variable resistors: fine adjustment, rheostat type.
- .5 Phasing marked on input and output terminals, viewed from front of equipment:
 - .1 Left to right.
 - .2 Top to bottom.
 - .3 Front to back.
- .6 Indicator lamps: long life incandescent or neon, rated for continuous duty, with sockets having adequate heat dissipation of lamps and dropping resistor if used.
- .7 Solid state circuits used where more reliable than mechanical timers or control relays.
- .8 Standard components available from commercial sources used throughout, with ten (10) years minimum shelf life.
- .9 Arrangement to permit easy removal of defective components to facilitate servicing by replacing with stock spares.
- .10 Small components, related to specific function, removable plug-in modular sub-assembly or printed circuit card.
- .11 Heavy sub-assemblies easily accessible, or slide on runners of anti-friction material, and have flexible leads and bolted connections.
- .12 Components and sub-assemblies accurately made for interchangeability.

2.5 Enclosure

- .1 Dead front free standing sheet steel minimum 2.5 mm thick, CSA Enclosure 1A.
- .2 Access preferably from front only, or from front and rear.
- .3 Meters, indicating lamps and controls group mounted in panel front.
- .4 Panel front enclosed by hinged doors to prevent tampering and to protect instruments and controls during shipping. Doors formed wrap-around type, rigid, to open and close smoothly, locking type handle with two (2) keys. Hinges to permit doors to be lifted off cubicle.
- .5 Cubicle height not to exceed 1.8 m.

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- .6 External cable connections at top of cubicle through bolted plate for drilling at Site to suit.
- .7 Ambient temperature range during operation -20°C to $+40^{\circ}\text{C}$. Natural or forced ventilation as required. For forced ventilation power from inverter output and fan directly driven by single phase motor mounted on vibration isolators. Each enclosure to have redundant fans, with fan failures alarmed. Air inlet and outlet openings protected with screens and metal guards.
- .8 Disposable air filters on fan cooled enclosures. Method of attachment and opening locations to make removal convenient and safe.
- .9 Maximum operating sound level not to exceed 80 db(A) as measured on sound level meter with A weighting and slow response, at a distance of 1.0 m.
- .10 Enclosure frames interconnected by ground bus with ground lug for connection to ground.

2.6 Rectifier

- .1 Input power supply from:
 - .1 AC mains.
- .2 Input disconnect: bolt-on molded case three pole air circuit breaker, quick make, quick break type for manual or automatic operation, temperature compensated for 40°C ambient, magnetic instantaneous trip element.
- .3 Isolating transformer: connected between AC input and rectifier input.
- .4 Surge suppressor: to protect equipment from supply voltage switching transients.
- .5 Rectifier:
 - .1 Silicon controlled rectifier assembly or sealed silicon diodes.
- .6 Filter: for rectifier DC output.
- .7 Fuse: to protect DC output.
- .8 Meters:
 - .1 DC voltmeter, switchboard type, accuracy $\pm 2\%$ of full scale, to measure rectifier output voltage.
 - .2 DC ammeter, switchboard type, accuracy $\pm 2\%$ of full scale, to measure rectifier output current.
- .9 Adjustments and controls:

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- .1 Line voltage adjusting taps to allow for +/-10% variation from nominal.
- .2 Manual adjustment of float voltage with range of +/-5%.
- .3 Manual adjustment of equalizing voltage.
- .4 Automatic current limiting on rectifier adjustable between 80 and 120% of normal rating.
- .5 Provision to disconnect rectifier from inverter and battery if rectifier DC output exceeds safe voltage limits of battery.
- .10 Meters, adjustments, and controls to be grouped on front panel.
- .11 Performance of rectifier:
 - .1 Automatically maintain battery in fully charged state while mains power available, and maintain DC float voltage within +/-1% of setting, no load to full load, during mains voltage variations up to +/-10%.
 - .2 Battery charging rate such that after battery has provided full load power output for specified duration, charger returns battery to 95% of fully charged state in 4 h.
 - .3 Automatic equalize charging circuit to initiate equalize charging of battery for 24 h after discharge of 5% of ampere hour battery rating.
 - .4 Manually initiated equalize charging feature with automatic timer adjustable from 0 to 24 h to return unit to float charge.

2.7 Inverter

- .1 Input power supply from:
 - .1 Rectifier DC output.
 - .2 Battery DC output.
- .2 Input disconnect: bolt-on molded case, single pole, circuit breaker, quick make, quick break type, for manual or automatic operation, temperature compensated for 40°C ambient, magnetic instantaneous trip element.
- .3 Input filter: with separately fused computer grade capacitor banks and indicator lights, to eliminate inverter source noise and restrictions on input cable length.
- .4 Power stage: high frequency switching type, dual cooled disc type SCR. Components, solid state devices capable of satisfactory operation under ambient conditions of -35°C to +55°C.

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- .5 Logic module:
 - .1 Integrated circuit logic.
 - .2 Silicon semiconductors.
 - .3 Plug-in modules.
 - .4 Gold plated plug-in connector.
 - .5 Front accessible field adjustments for voltage and frequency.
 - .6 Front accessible test points: suitably protected coded pin jacks.
 - .7 Frequency reference module.
 - .8 Current limiting module, automatic high speed by controlled reduction of output voltage.
 - .9 Voltage regulator.
- .6 Output filter: output of high frequency switching stage contains elements of carrier frequency which are filtered to low harmonic sine wave.
- .7 Meters:
 - .1 AC voltmeter: switchboard type, accuracy +/-2% of full scale, to measure inverter output voltage with 7 position selector switch to select phase to neutral, phase to phase, off.
 - .2 AC: switchboard type, accuracy +/-2% of full scale, to measure inverter output current with 4 position selector switch to select each phase and off.
 - .3 Wattmeter: switchboard type, accuracy +/-2% of full scale to measure inverter load.
 - .4 Frequency meter: switchboard type, scale 58 to 62 Hz, pointer type, to measure inverter output frequency.
 - .5 Synchroscope: with switch to check inverter output potential against supply mains potential.
- .8 Output disconnect: bolt-on, molded case, three pole circuit breaker, quick make, quick break type, for manual or automatic operation, temperature compensated for 40°C ambient, magnetic instantaneous trip element.
- .9 Meters and controls: grouped on front panel.

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2.8 Battery

- .1 Battery type and electrical characteristics:
 - .1 Discharge current to supply inverter at full load output, for 5 min.
 - .2 Sealed lead acid. Ten (10) year life.

2.9 Static Bypass Switch

- .1 Two (2) solid state closed circuit automatic transfer switches.
- .2 Logic unit with three (3) normal source voltage sensors, which monitor over-voltage under-voltage and loss of voltage.
- .3 High speed automatic transfer from normal voltage to alternate source when:
 - .1 Normal source voltage lost: transfer time and sensing $\frac{1}{4}$ cycle.
 - .2 Normal source: under-voltage at 80% of nominal value adjustable.
 - .3 Normal source: over-voltage at 110% of nominal value.
 - .4 Loss of normal source static switch continuity.
 - .5 Short circuit on normal source trips normal source breaker.
- .4 Return to normal source:
 - .1 When normal source remains within return voltage limits of 95% to 110% of nominal value (adjustable) for approximately 1 s timing interval, circuit checks voltage balance and phase synchronization, then initiates return with zero switching time.
- .5 Switch position lights and contacts.
- .6 Synchronizing verification light.
- .7 Manual reset push-button.
 - .1 Transfer test switch.
- .8 Alternate power source monitor light.
- .9 Accessories:
 - .1 Manual bypass switch for maintenance and testing without load disturbance.

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- .2 Continuity monitor: automatic transfer to alternate source in event of static switch discontinuity.
- .3 Alternate power source loss alarm contacts.

2.10 Operating Devices

- .1 Operating Accessories:
 - .1 Counter for number of failures of normal mains AC power: non-reset type, zero to 99,999 operations.
 - .2 Elapsed time meter indicating accumulated time of battery discharge in minutes non-reset type, zero to 99,999.9 minutes.
 - .3 Elapsed time meter indicating accumulated time of inverter operation in hours, non-reset type, zero to 99,999.9 hours.
- .2 Mode lights mounted on front panel to indicate:
 - .1 AC output on inverter – green.
 - .2 AC input available – green.
 - .3 Inverter and AC input synchronized – green.
 - .4 Inverter and AC input not synchronized – amber.
 - .5 Static bypass switch in bypass position – red.
 - .6 Over-temperature alarms:
 - .1 Rectifier – red.
 - .2 Inverter – red.
 - .3 Bypass switch – red.
 - .7 Cooling fan fuse open – red.
 - .8 Inverter output over voltage – red.
 - .9 Inverter output under voltage – red.
 - .10 Battery over-voltage – red.
 - .11 Battery under-voltage – red.
 - .12 Inverter fuse/breaker open – red.

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- .13 Rectifier fuse/breaker open – red.
- .14 Static bypass switch fuse/breaker open - red.
- .15 UPS on battery operation – red.
- .16 Rectifier in equalize mode – amber.
- .17 Battery discharging indicator - red, to change from steady to flashing during final 5 to 10 minutes of battery duration.
- .3 Alarms: audible alarm when any mode light shows red. Silence pushbutton not to extinguish trouble light.
- .4 Remote status alarm system:
 - .1 Two (2) status alarm annunciators for indication at two (2) remote points, up to 10 m distant. Illuminated nameplates installed in cabinets for flush mounting in existing panels.
 - .2 Transmission cable supplied and installed by Contractor.
 - .3 Transmission distance 30 m.

2.11 Finishes

- .1 Apply finishes in accordance with Section 16010 - Electrical General Requirements..
- .2 Cubicles:
 - .1 Inside finish: white.
 - .2 Exterior finish: Manufacturer's standard colour.
 - .3 Exterior hardware and trim: corrosion resistant and not requiring painting such as stainless steel or aluminum.

2.12 Equipment Identification

- .1 Provide equipment identification in accordance with Section 16010 – Electrical General Requirements.
- .2 For major components such as AC input breaker, inverter breakers, bypass switch: size 4 nameplates.
- .3 For mode lights, alarms, meters: size 2 nameplates.

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2.13 Fabrication

- .1 Shop assemble:
 - .1 Rectifier unit.
 - .2 Inverter unit.
 - .3 Bypass switch unit.
 - .4 Battery rack and battery.
- .2 Interconnect units, and add remote mode lights, alarms and controls to produce complete uninterruptible power system before requesting Contract Administrator to witness factory tests.

2.14 Approved Manufacturers

- .1 The following are approved manufactures of this equipment
 - .1 Liebert - UPStation S3
 - .2 Powerware
 - .3 APC - DP330E
 - .4 Powerco

3. EXECUTION

3.1 Installation

- .1 Locate UPS cubicles, battery rack and battery as indicated.
- .2 Assemble and interconnect components to provide complete UPS as specified.
- .3 Connect AC mains to main input terminal
- .4 Connect UPS output to load.
- .5 Start-up UPS and make preliminary tests to ensure satisfactory performance.

3.2 Testing

- .1 Perform tests in accordance with Section 16980 – Testing, Adjusting and Balancing of Electrical Equipment and Systems and Section 01670 –Commissioning.

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.2 Provide:

- .1 Competent field personnel to perform test, adjustments and instruction on UPS equipment.
- .2 Dummy load adjustable to 150% of system rated output.
- .3 Notify Contract Administrator ten (10) Business Days in advance of test date.
- .4 Tests:
 - .1 Inspection of cubicles, battery rack and battery
 - .2 Inspection of electrical connections
 - .3 Inspection of installation of remote mode lights and alarms
 - .4 Demonstration of system start-up and shut-down
 - .5 Run UPS for minimum period of 4 h at full rated load to demonstrate proper operation with AC mains input, emergency generator input, no AC input
 - .6 Discharge battery by operating UPS with AC mains open for specified duration of full load. Record readings of temperature of each cell
 - .7 Recharge battery automatically with full rated load on UPS for 4 h and record readings of voltage of each cell.

3.3 Training

- .1 Provide demonstration and training on equipment operation and maintenance in accordance with Section 01664 – Training and Section 16990 – Electrical Equipment and System Demonstration and Instruction

3.4 Extended Warranty

- .1 The Contractor hereby warrants the battery against defects in material and workmanship in accordance with GC: 13 and D25, but for ten (10) years. This warranty is for 100% replacement for the first year and prorated in equal yearly decreasing increments for the remaining nine (9) years until the expiration of the warranty at the end of ten (10) years from the date of Total Performance.

END OF SECTION