PART III – SECTION J
ATTACHMENT J.1

Uninterruptible Power Supply Equipment Specification (UES)

Performance Goals and Operation Characteristics

Version 2

12/16/05

Part 1 General

1.0 UPS Definition:
The system shall continuously supply regulated AC power to loads and shall be capable of providing power during loss or interruption of input AC by using energy stored in a battery bank. The UPS shall be capable of suppressing transient voltage conditions. Input power will be AC power supplied from either the electric utility or an engine generator. The UPS, as specified by contract, shall consist of a single non-redundant module, three phase power configuration. Three-phase power input and three-phase output: sized from 10kVA to 500kVA. The UPS module shall include internal automatic transfer capability and control circuitry. And, an external manual operated maintenance bypass cabinet.

1.1 Major Component List:
Each UPS system furnished by the Contractor shall include:

a. Static UPS unit shall have all filters, dual inputs, static bypass, invertors/converters, and any other subcomponents needed to make a complete operating unit with exception of system components listed in b. through h. below.
b. Battery System. Valve Regulated Lead Acid (VRLA) battery system includes cabinet/rack, batteries, interconnecting cables, built-in disconnect, and all necessary hardware to complete the battery unit. Flooded Cell Battery (FCB) system includes rack, batteries, interconnecting cables, and all necessary hardware to complete the battery unit.
c. Battery Monitor.
d. System interface for external software monitoring.
e. Remote hardwired annunciation panel.
f. Manual maintenance bypass equipment necessary to completely isolate the UPS unit.
g. Battery Lift.
h. Load Bank.

1.2 Reserved.

1.3 Environmental requirements:

1.3.1 Storage ambient temperature: -20C to 70C

1.3.2 Operating ambient temperature UPS unit: 0C to 40C

1.3.3 Operating ambient temperature batteries: 15C to 27C

1.3.4 Relative humidity: 5 to 95%, non-condensing.

1.3.5 Altitude: The UPS shall operate at all altitudes between 0 and 3,300 feet without de-rating performance. The contractor shall provide de-rating data for operation between 3,300 and 10,000 feet in 1000-foot increments.

Part 2 Equipment Characteristics and Performance

2.0 General: UPS shall be a single module of on-line technology that meets the stated performance requirements. The UPS system control shall provide synchronization control circuits, connection control circuits, disconnection control circuits, system instrumentation, system status indicators, system alarms and system diagnostic for Remote Maintenance Monitoring and battery monitoring. The UPS will be of such a design that when operating on a standby engine generator with between 30% to 80% UPS loading that the UPS will be able to synchronize to that generator source. And, the UPS will be able to synchronize to a generator while the generator is supporting an unloaded UPS system.

2.1 UPS Performance Ratings: The UPS shall supply fully conditioned and continuous power during normal operations. The UPS shall also be capable of providing continuous rated power during loss or interruption of input AC power by using DC power stored in the battery bank. Under specified conditions, external or internal failures and normal switching, the UPS shall automatically, without interruption, transfer the load by use of the static transfer switch to the bypass feeder. The UPS shall automatically reverse transfer from utility bypass operation to UPS operation without output voltage interruption when load conditions are within the system rating.

2.2 UPS continuous output capacity rating: The vender shall offer one model in the following three-phase UPS kVA group ratings. For 208/208 volt they are: 10-19 kVA, 20-29 kVA, 30-39 kVA, 40-49 kVA, 50-65 kVA, 66-80 kVA, 81-100 kVA, 101-150 kVA. For 480/480 they are: 20-29 kVA, 30-39 kVA, 40-49 kVA, 50-65 kVA, 66-80 kVA, 81-100 kVA, 101-150 kVA, 151-250 kVA, 251-300 kVA, 301-400, and 500 kVA.

2.3 UPS Battery Capacity: The battery unit must provide 10 to 15 minutes of 100% rated load back-up time for each UPSs rated up to 150 kVA and at least 8-minutes for UPSs rated from 151 to 500 kVA.

2.4 Electrical Input Requirements.

2.4.1 Input voltage: Three-phase: 208/120 volts, 3 Phase, 4-wire, wye
480/277 volts, 3 Phase, 4-wire, wye.
480 volt, 3 Phase, 3-wire wye

2.4.2 Input voltage range: +10%, -15% steady state.

2.4.3 Input frequency: 60 hz +/-5% with other levels programmable.

2.4.4 Inrush current: Inrush current values shall not exceed these values at these specific times:

a. At 0.01 second, 8-times the steady state rating of the unit. Peak current measurement.

b. At 0.1 second, 3-times the steady state rating of the unit. RMS current measurement

c. And at 1 second, steady state. RMS current measurement.

Vender shall provide actual inrush current values for each UPS unit proposed under this contract.

2.4.5 Power walk-in: 0 to 100% over a 10-second period, other times programmable.

2.4.6 Input Power Factor (PF): (ratio of kW to kVA) Power Factor values between 30% load and 80% load shall not be less than 0.90 lagging. At no time during the UPS operation shall the PF become leading. Load is full rated capacity of the UPS.

2.4.7 Input Total Harmonic Distortion (THD), Current: THD values between 30% and 80% load shall not exceed 10%. Load is full rated capacity of the UPS. This THD value is applicable for electrical service provided by commercial source where that source impedance, as represented by I_{SC} in paragraph 10-4 of IEEE 519-1992, is 20 or greater than the UPS full rated Load, I_L. And, a soft power source, such as an engine generator, when the source impedance, as represented by I_{SC} in paragraph 10-4 of IEEE 519-1992, is 9 or less than the UPS full rated load, I_L.

2.4.8 Dual Input Feed: The UPS shall have separate power input feeds for the AC/DC converter/rectifier and internal static bypass switch.

2.5 Electrical Output Requirements.

2.5.1 Output voltage: Three-phase: 208/120 four-wire plus equipment ground and 480/277 volt, 4-wire, wye, plus equipment ground. With ability to remove neutral to ground bond.

2.5.2 Output voltage regulation Steady State:

a. +/- 1% for a static 100% balance load.
b. +/- 3% for a static 100% unbalance load. (Phase A – 100%, Phase B – 0%, Phase C – 0%)

2.5.3 Output Frequency:

a. Frequency "free run" +/- .01 Hz
b. Frequency "Sync range" +/- 0.5 Hz,
c. Frequency maximum slew rate 1hz/second.

2.5.4 Output Voltage Harmonic Distortion: The UPS shall continuously function, without capacity de-rating, when supplying a 100% distorted load (2.5.4.b) with phase displacement no greater than paragraph 2.5.6c.

a. 3% THD maximum and 1% any single harmonic for 100% linear load.
b. 5% THD maximum for a 100% nonlinear load, crest factor 3:1.

2.5.5 Output Voltage Transient Recovery Time: Voltage shall fully recover to within nominal voltage regulation limits within 16.6 - milliseconds or less.

a. +/- 3% for a 50% load step.
b. +/- 5% for a 100% load step.

2.5.6 Output Voltage Phase displacement:

a. 120 degrees +/- 1 degree for balanced load.
b. 120 degrees +/- 1 degree for 50% unbalanced load. (Phase A - 100%, Phase B – 50%, Phase C - 50%)
c. 120 degrees +/- 3 degrees for 100% unbalanced load. (Phase A – 100%, Phase B – 0%, Phase C – 0%)

2.5.7 Output Overload Current Overload at Full Output Voltage Capability:
a. 125% for 10 minutes in normal operation.
b. 150% for 60 seconds in normal operation.
c. 167% of full load current (instantaneous).

2.5.7.1 Current Limit: 212% full load current if bypass is not available.

2.5.7.2 Fault Clearing: Sub-cycle current of at least 300% but not more than 500% of normal full load current.

2.6 Battery DC ripple voltage.
a. During either cycle service or bulk phase of charging DC ripple voltage is maximum 1.5% RMS of the float voltage.
b. During float phase of charging DC ripple voltage is maximum 0.5% RMS of float voltage.

2.7 Low battery voltage protection: To prevent total discharge of the battery, the UPS shall automatically shut-down when the battery voltage reaches a programmable minimum voltage level. If the shut-down was caused by loss of AC input, then when power is restored normal system operation automatically resumes.

2.8 System Operation, Normal System Operation: The battery unit shall not be required to assume any portion of a critical load increase in normal operation. The UPS shall continue to function in the normal mode of operation with or without a DC source.

2.8.1 Normal Mode: During normal operation the UPS shall be used to provide precise regulated and transient free power to the electronic equipment load. The primary AC source shall be used to supply power to the rectifier charger. The rectifier charger shall provide regulated DC power to support the inverter and simultaneously maintain the battery in a fully charged condition. The inverter shall convert the DC power into regulated AC power for the load.

2.8.2 Emergency Mode: Upon failure of the primary AC power, input power for the inverter shall automatically be supplied from the battery. When normal power is restored, input power for the inverter and for recharging the battery shall automatically be supplied from the rectifier charger. If the input AC power does not return, the UPS shall automatically shut down in an orderly manner when the discharge limit of the battery is reached.

2.8.3 Bypass Mode: If the UPS must be taken out of service for maintenance or an internal failure, the static switch shall transfer the load to the alternate source without an interruption. Re-transfer of the load shall be accomplished by synchronizing the UPS to the alternate source, paralleling the inverter with the alternate source, and then disconnecting the alternate source.

2.8.4 Downgrade Mode: If the battery must be taken out of service for any reason, it shall be disconnected from the rectifier charger and inverter by means of a circuit breaker. The UPS shall, upon receipt of a remote signal, open the battery circuit breaker and isolate the battery from the UPS system. Remote opening of the battery circuit breaker shall activate an individual battery circuit breaker alarm and the summary alarm. The UPS shall continue to function and meet the performance criteria specified except for the protection time specified. If there is a loss of input power to the module when the battery has been disconnected, the logic shall immediately isolate the module by opening the output breaker or contactor to prevent a reverse power condition.

2.9 Short Circuit Withstand.

2.9.1 The inverter shall be able to sustain a short circuit current across its output terminals, of 300% of its rated output for one cycle, after which it shall current limit to 150% until the fault clears or the UPS system transfers to bypass.

2.9.2 Inverters shall be provided with short circuit protection circuitry such that in the event of a direct short at the UPS system output it will current limit and attempt to clear the fault. The module shall have the capability to isolate itself fast enough from the output bus so that the reverse power into the fault from the bypass line will not cause the entire UPS output to collapse below the acceptable limits for the operation of the computer load. At the Governments option this feature will be demonstrated at the factory by shorting the output of the inverter to ground and monitoring the UPS output bus. However, if the fault is sustained and the UPS system is unable to transfer to bypass due to unavailability of bypass power, inverters shall shut down in a controlled manner without damage or blowing fuses, followed by tripping of module output circuit breakers. All inverters shall then power up automatically (without operator intervention) and be ready for reconnection to the module bus by manual closure of module output breakers. At the Governments option this feature will be demonstrated at the factory by prohibiting the static bypass function (bypass breaker drawn out of connected position) and subjecting the UPS system output to a three phase short via a three phase contactor connected to all three phase buses.

2.9.3 The UPS shall be listed as meeting the parameters of UL Standard 1778.

2.10 System AC to AC Efficiency: The UPS AC to AC minimum efficiency at rated input and output voltage is 89%, at 100% linear load, nominal input voltage, with batteries fully charged.

2.11 Acoustical noise: Maximum 70 dBA of noise, measured at 1 meter from the operator surface.

2.12 UPS Module Design

2.12.1 Reliability: The documented reliability of each module, which is the basic element in the system, shall not be less than 60,000 hours mean time between failures (MTBF) ,without static bypass. The above figure should be substantiated by documented analysis and calculated based on MIL-STD 217 and IEEE STD 493-1990.

2.12.2 Maintainability: Modular sub-assembles: for ease of maintenance and service, the UPS must have field replaceable modular sub-assemblies serviceable from the cabinet front panel. The UPS system shall not require periodic maintenance or

inspections more than twice each year; with the exception of air filter changes as needed. No visit for routine or periodic maintenance shall require more than 4 staff-hours for the semi-annual visit.

2.12.2.1 Malfunction diagnosis

a. The UPS shall have self-diagnostic capabilities to determine malfunctions and failures to the line replaceable unit (LRU) level, except individual batteries, that would ultimately result in the operation of a protective device.

b. Malfunctioning LRUs shall be correctly identified 90% of all cases.

c. The remaining 10% of malfunctioning LRUs shall be isolated to not more than three possible LRUs.

d. Local alarms shall be supplied to provide maintenance personnel with information regarding the reason for the shutdown or incipient failure.

e. This same information shall be capable of being transmitted to an interface with remote capabilities.

f. Visual and audible indicators shall annunciate the malfunction of a protective device or circuit.

g. The indicators and manufacturer's instruction manuals shall be sufficient to enable FAA personnel to verify the existence and location of the fault or malfunction and determine the steps necessary to restore the UPS system to service.

2.12.2.2 Mean Time To Repair (MTTR):

The UPS shall be configured so that system restoration, following a failure, can be accomplished by the replacement of a LRU(s). Mean time to repair the UPS, following a failure, shall not exceed 60-minutes, assuming spare components, subassemblies and experienced technician are available on site. MTTR is the mean time to repair all of the removable items in a system for corrective maintenance. MTTR is defined as beginning when the trained technician arrives at the UPS location. It includes the total time required to isolate and replace the defective LRU and return the UPS to normal operation.

2.12.3 Internal Bypass Module:

a. The UPS internal bypass module shall be rated for continuous duty and be capable of operation even if UPS battery unit fails or is disconnected.

b. The static bypass switch shall sense and automatically transfer the critical load, in ¼ cycle, provided bypass is synchronized with the UPS output, after one of the following conditions:

1) DC to AC converter overload beyond rating.
2) Energy storage unit Battery runtime expired and bypass available.
3) DC to AC converter failure.
5) Fatal error in control system.

c. The static bypass switch shall automatically retransfer from bypass to the DC to AC converter, when one of the following conditions occurs:

1) After an instantaneous overload induced transfer has occurred and the load current has returned to less than 100% of the system rating, within 1-minute.
2) The UPS DC to AC converter is operational and on.

2.12.4 Grounding and Surge Protection.

2.12.4.1 Input Surge Protection: UPS systems shall meet IEEE 587, (ANSI Standard C62.41), Categories A & B (6kV).

2.12.4.2 EMI Suppression: Radiated and conducted EMI shall be suppressed to ensure that computer systems, or other similar electronic systems shall neither adversely affect the UPS system nor be adversely affected by the UPS system. The system will not be damaged, nor operate falsely, when operated in the vicinity of a hand held radio transceiver, 5 Watts, 50-900 MHz range transmitting within two (2) feet of the equipment with doors open and/or closed. Also, UPS systems shall meet FCC Class A, Subpart J of Part 15.

2.12.4.3 Electrostatic Discharge: UPS systems shall withstand 25 kV electrostatic discharge without damage or disturbance to the load.

2.12.5 Module Control Panel: The full UPS operation shall be provided through the use of digital power quality control logic. All operation and parameters shall be firmware controlled, thus eliminating the need for manual adjustments or potentiometers. The logic shall include a self-test and diagnostic circuitry such that a fault can be isolated down to the printed circuit assembly or plug-in power assembly level. Every printed circuit assembly or plug-in power assembly shall be monitored. Diagnostics shall be performed via a PC through the local diagnostics port on the unit, or via a modem through the RS232/485 communication port.

2.12.5.1 All system logic shall be at the UPS module level for highest reliability. All metering shall be digital with a better than 1% accuracy. All metering and alarms with time stamps shall be available through the RS 232/485 communications port (Note: Ethernet monitoring and direct connect laptop/PC monitoring may use different communications ports. Vender shall provide both communication ports or adaptors as necessary.) The following minimum metering, controls and alarms shall be provided:

1. Module metering shall include voltmeter and ammeter with controls to allow monitoring of any AC phase voltage line-to-line, and any AC line current for either input or output as well as DC voltage and current. Metering shall also include: percent load, power factor, kVA, kW, battery current (charge/discharge).
2. Time remaining on battery and battery time available shall be displayed and the system shall have the ability to interface this time remaining feature to an unattended shutdown system in the Owners file servers.
3. Inverter “on-off” controls.
4. Module input, output, and DC device “off” control.
5. Lamp test.
6. Alarm reset.
7. Mimic bus diagram of the rectifier/charger, inverter, input breaker, output breaker, DC breaker, battery disconnect and the battery.
8. Modular alarms (Audible and Visual) as a minimum shall be:
    a. Input Fail
    b. Rectifier Fuse
    c. DC Over voltage
    d. Rectifier Over temperature
    e. DC Ground
    f. Battery Discharge
    g. Low Battery Warning

h Low Battery Shutdown
i. Battery Disconnected
j. Inverter Fuse Ph A
k. Inverter Fuse Ph B
l. Inverter Fuse Ph C
m. Inverter Over temperature
n. Output Under voltage
o. Output Over voltage
p. Output Overload
q. Fan Failure
r. Rectifier Failure
s. Inverter Failure
t. Emergency Off

Additionally, these alarms shall be connected through Form C contacts to a customer alarm terminal strip for remote alarm indication.

2.12.5.2 Module Power Flow Indications: A power flow diagram shall graphically depict whether the load is being supplied from UPS or battery and provide, on the same LCD screen, the status of the following components:

1. Module input circuit breaker
2. Battery circuit breaker
3. Module output circuit breaker

2.12.5.3 UPS module input and output breakers shall be manually and electrically operated, molded case, automatic circuit breakers. The output breaker interrupting rating shall be greater than the maximum UPS system short circuit output.

2.12.6 System Controls. The System Control shall denote the monitoring and controlling circuitry for the system level functions. The control panel shall be located on the control section door.

1. Manual Load Transfer Operation: A manual load transfer between the UPS system and bypass line shall be initiated from the control panel. A manual transfer shall utilize the system bypass and isolation breakers to create a make-before-break overlapped transfer.
2. Automatic Load Transfer Operation: Automatic load transfers shall be initiated when a sustained system overload occurs. The static switch shall be used to permit an instantaneous connection of the bypass source to the critical load. This occurs when an overload exceeding the capacity of the Module Unit is detected and the overload remains for a period longer than the inverse time overload curves permits, if a module drops off line during operation, or if a critical load output bus voltage deviation is detected. In these cases the static bypass switch shall be used to enable an uninterrupted transfer when the inverter output is synchronized with the bypass source. If the two sources are not synchronized an interrupted transfer shall occur. The 100% rated continuous duty static switch shall operate and the Static Bypass Breaker shall close.
3. Automatic Load Retransfer Operation: When the load is automatically transferred to the bypass source due to an overload condition, the system control logic shall cause the automatic retransfer of the load back to the UPS system only after the overload has been removed. The system logic shall allow 0 to 5 re-transfers (adjustable) within any one hour period to

prevent cyclical transfers caused by overloads. An automatic retransfer prohibit selector switch shall be provided.

4. The system shall be equipped with a fast detection circuit which will continuously monitor the system output bus and transfer the load to bypass in the event the UPS output breaker is accidentally opened due to a breaker malfunction or due to an operational error. The transfer shall be fast enough to maintain the output voltage transient within the specified limits.
5. Maintenance Bypass: A manual closed transition load transfer between the UPS system and the maintenance bypass line shall be initiated from the control panel. Control logic shall be provided for a manually initiated automatic load transfer. Dead bus relays and synchronization check relays shall be used to prevent operator error or inadvertent loss of the critical load. Similar control logic shall be provided to permit a manually initiated automatic load retransfer back to the UPS system.
6. Provide connection points for the installation of a Power Quality Monitoring system at the output of the UPS. The monitoring terminal points shall be fuse protected.

2.12.7 Display and Controls

2.12.7.1 UPS Control Panel: The term UPS control panel denotes that portion of the UPS containing the display panel and control functions. Each UPS Module Unit shall be provided with a control section to provide complete monitoring and control through the use of menu-prompted commands. The display and control panel shall be mounted on the control section door.

2.12.7.2 Logic: Module, logic and control programming shall be resident in Application Specific Integrated Circuits. Rectifier, inverter, and system control logic shall be solid state. Switches, contacts and relays shall only be used to signal the logic system as to the status of mechanical devices or to signal user control inputs. Relays shall be used to isolate the logic for customer external status and alarm signaling.

2.12.7.3 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 wave forms typical of computers and other sensitive loads. The following parameters shall be displayed:

1. UPS Module:
    a. Input voltage.
    b. Input current.
    c. Battery voltage.
    d. Battery charging/discharging current.
    e. Output voltage.
    f. Output current.
    g. Output kW.
    h. Output kVA.
    i. Output frequency.
    j. Bypass input voltage.
    k. Bypass input frequency.
    l. Output voltage.
    m. Output frequency.

n. Load current.
o. Load kW.
p. Load kVA.

2.12.7.4 Power Flow Indications: A power flow diagram shall graphically depict whether the load is being supplied from UPS, bypass or battery and provide, on the same LCD screen, the status of the following components in the UPS Module.

1. AC input circuit breaker.
2. Battery circuit breaker.
3. Inverter output circuit breaker.
4. Bypass and UPS output circuit breakers.
5. Static Transfer Switch (Connected, Disconnected).
6. Maintenance Bypass and System isolation breakers.
7. Normal Power Available.
8. Maintenance Bypass Power Available.
9. Utility Power Available.
10. Generator Power Available.

2.12.7.5 Battery Status Indicator: A battery status indicator at the module unit shall display DC alarm conditions, shutdown voltages and the present battery voltage and current 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.

2.12.7.6 Alarms: Alarm conditions shall be reported at the UPS Module Unit. The control panel shall report the alarms listed below. Each alarm shall be visually displayed in text form and an audible alarm will sound for each alarm.

1. Input Fail.
2. DC Ground Fault.
3. DC Capacitor Fuse Blown.
4. Battery CB Open.
5. Battery Discharging (Current Driven).
6. Low Battery Warning.
7. Low Battery Shutdown.
8. DC Over-voltage Shutdown.
9. Inverter Fuse Blown.
10. Overload Shutdown .
11. Hardware Shutdown .
12. Reverse Power .
13. Ambient Over-temperature .
14. Equipment Over-temperature.
15. Over-temperature Time-out.
16. Rectifier Fuse Blown.
17. Blower Failed.
18. Input Current Unbalanced.
19. Inverter Non-synchronized.
20. Load On Bypass.
21. Output Under-voltage.
22. Output Over-voltage.
23. Output Over/Under Frequency.
24. Overload Transfer.
25. Manual Reset/.Retransfer.
26. Static Switch Unable.

27. Auto Transfer to Bypass.
28. Auto Retransfer Primed.
29. Bypass Not Available.
30. Bypass Phase Sequence Wrong.
31. Module Summary Alarm.
32. Communication Failure.
33. Emergency Off.
34. Overload.
35. Control Power Fail .
36. Summary Alarm and remotely through Form C contacts .

2.12.7.7 Controls: Control functions shall be:

1. UPS/Bypass transfer push-button.
2. AC output voltage adjust.
3. Battery circuit breaker trip push-button.
4. Emergency shut down push-button with protective cover.
5. Horn Off push-button.
6. Control Enable push-button.
7. Display control push-button: Up, Down, Select.
8. Alarm Reset push-button.
9. Output Trip push-button.

2.12.7.8 Manual Procedures: Start-up, load transfers and shutdown procedures shall be detailed on the display panel in text and graphic form.

2.12.7.9 Self-Diagnostics:

1. Present Status Screen: The control system shall monitor and display all of the flowing parameters in a present status screen:
   a. Input Voltage, Line-To-Line for all three phases .
   b. Input Current for all three phases.
   c. Bypass Voltage, Line-To-Line for all three phases.
   d. Output Voltage, Line-To-Line for all three phases.
   e. Output Current for all three phases.
   f. Output Frequency.
   g. Battery Voltage.
   h. Battery Amps.
   i. Load kVA.
2. History Status File: A history status file shall contain all of the information in the present status screens. The control system shall maintain this information in discreet 4 millisecond frames updating memory on a First-In/First-Out basis. This shall provide status recall of a period of at least 252 milliseconds (63 frames); 156 milliseconds before the malfunction fault (30 frames), the fault frame, and 92 milliseconds after the malfunction (23 frames). Each frame shall display four 1 millisecond time period slices with 1 millisecond resolution for output voltage and current.
3. Event History File: The control system shall maintain an event history of the alarm conditions that have occurred during system operation. System memory shall be capable of storing at least 128 events for recall.
4. Diagnostic Aids. The UPS shall be provided with the following diagnostics integral to the controlling circuit boards for additional troubleshooting and circuit alignment aids:
   a. Rectifier in control mode.
   b. UPS synchronizing with bypass.
   c. Positive DC bus ground fault.

d. Negative DC bus ground fault.
e. Bypass frequency higher than system output frequency.
f. Bypass frequency lower than system output frequency.
g. Automatic static transfer switch lockout.
h. Command given to close UPS (system) output circuit breaker.
i. Command given to close bypass circuit breaker.
j. Command given to open UPS (system) output circuit breaker.
k. Command given to open bypass circuit breaker.
l. Under voltage release for battery disconnect switch.
m. Under voltage release for input circuit breaker.

2.12.7.10 Monitoring Capability: UPS control circuits shall be capable of interfacing with third party monitoring software FAA's Environmental Remote Monitoring (ERMS) and Modbus via the RS232 or RS485 port in an open protocol environment. Interface via communication ports shall be built into the UPS or included with the UPS unit. (Note: Ethernet monitoring and direct connect laptop/PC monitoring may use different communications ports. Vender shall provide both communication ports or adaptors as necessary.)The site-monitoring signal processing module shall be built into the system logic. The following shall be available for external monitoring:

1. Metering:
   a. Bypass volts (line-line and line-neutral, all phases).
   b. Critical bus volts (line-line & line-neutral, all phases).
   c. Critical bus current (all phases).
   d. Critical bus frequency.
   e. Critical bus kVA.
   f. Critical bus kW.
   g. Critical Bus Capacity.
   h. Module DC volts.
   i. Module battery amps (+/-).
   j. Module input volts (line-line, all phases).
2. Digital Alarms:
   a. Battery Discharging.
   b. Low Battery Warning.
   c. Output Overload .
   d. Fuse Failure.
   e. Ambient Over-Temperature.
   f. DC Ground.
   g. Battery CB Open.
   h. Blower Failure.
   i. Control Power Failure
   j. Overload Shutdown.
   k. Output Overload.
   l. Emergency Off.
   m. Load On Bypass.
   n. Static Switch Disabled.
   o. Output Over/under voltage.
   p. Module Summary Alarm .
   q. System Summary Alarm .

2.12.7.11 System Status Panel

1. One panel shall be provided for each system. Panel shall consist audible and LED annunciation with each alarm LED latching until alarm condition

is eliminated. Audible alarm silence switch shall be provided. Panel shall include the following listed alarms and operation modes:

a. System Output Current (Digital Readout)
b. System Output Voltage (Digital Readout)
c. System Output kW(Digital Readout)
d. Critical Load On Ups (Green)
e. Normal Power Available (Green)
f. Bypass Power Available (Green)
g. Maintenance Bypass Power Available (Green)
h. Summary Alarm (Red)
i. Battery Under Discharge (Red)

2.12.8 Communication Hardware Interface: A communication interface shall provide the following communication ports. (Note: Ethernet monitoring and direct connect laptop/PC monitoring may use different communications ports. Vender shall provide both communication ports or adaptors as necessary.)

a. RS232 serial port for use with venders PC based software.
b. RS485 communications port.
d. Interface with engine generator/ATS, if applicable.
e. Interface connection to manual maintenance bypass Kirk key solenoid.
f. Hardwire connection for Remote Monitor Alarm Panel listed in Paragraph 2.13.5 below.

2.12.9 Remote Software Monitoring: The UPS shall have available interfaces to support remote monitoring for the following systems:

a. Modbus Protocol.
b. Modbus Ethernet communications.
c. Microsoft Windows XP, or latest version of MS Windows.

2.13 UPS Ancillary Equipment

2.13.1 Manual Maintenance Bypass (MBP) Switch. This switch shall be external to the UPS either housed in a floor mount cabinet or wall mount enclosure. The switch, as diagramed in appendix 1, shall be a make-before-break operation without disrupting the output to the critical load. The MBP switch consists of:

a. Three switch cabinet/enclosure.
b. Molded case switches, with 22,000 AIC rating.
c. Optional Kirk keys with key solenoid interlock linking the UPS and MBP.
d. MBP wired as shown in appendix 1 and 2 of this document.

2.13.2 Batteries. Provide both Valve Regulated Lead Acid (VRLA) and Flooded Cell Batteries (FCB) for use with the UPS units offered in the contract.

2.13.2.1 VRLA batteries shall conform to the following criteria:

a. Battery Cabinet Runtime Table: Provide a table indicating cabinet/rack model number and runtime in minutes for each UPS unit at 100% load.
b. Constant Power Discharge Ratings –Watts Per Cell @ (operating temperature, F & C): Each battery model shall have a chart indicating watts/cell for different Operating Time to End Point Voltages (in minutes) at End Point volts/cell range from 1.60 to 1.75.

c. Constant Current Discharge Ratings – Amperes @ (operating temperature, F & C): Each battery model shall have a chart indicating discharge amperes for different Operating Time to End Point Voltages (in minutes or hours) at End Point volts/cell range from 1.60 to 1.90.
d. Warranty: Provide manufactures battery warranty including, parts, labor, and shipping.
e. Case and Cover: Provide both non-flame retardant and flame retardant batteries. Flame retardant case and cover compliant with UL 1778.
f. Operating Temperature: Between 66^0 F and 77^0 F (19^0 C and 25^0 C.
g. The following shall be furnished with the VRLA battery string:

1. Batteries.
2. Battery Rack/Cabinet.
3. Inter-battery cables/connectors.
4. Tier-to-tier battery cables/connectors.
5. Battery to disconnect breaker cables/connectors.
6. Battery numbering.
7. DC Disconnect Breaker.

2.13.2.2 FCB. Batteries shall be wet cell, lead calcium stationary type.

2.13.2.2.1 FCB General Requirements.

a. Battery Runtime Table: Provide a table indicating rack model number and runtime in minutes for each UPS unit at 100% load.
b. Constant Power Discharge Ratings –Watts or kilo Watts Per Cell @ (operating temperature, F & C): Each battery model shall have a chart indicating watts/cell for different Operating Time to End Point Voltages (in minutes or hours) at End Point volts/cell range from 1.60 to 1.75.
c. Constant Current Discharge Ratings – Amperes @ (operating temperature, F & C): Each battery model shall have a chart indicating discharge amperes for different Operating Time to End Point Voltages (in minutes or hours) at End Point volts/cell range from 1.60 to 1.90.
d. Warranty: Provide manufactures battery warranty including parts, labor and shipping.
e. Operating Temperature: Between 66^0 F and 77^0 F (19^0 C and 25^0 C.
f. Flame-retardant cover: Compliant with UL94-V0/Limiting Oxygen Index 28% or greater.
g. FCB in single, two, three or four cells per battery/jar configuration.

2.13.2.2.2 FCB Battery Specifics.

1. The battery system shall have a minimum discharge cycle capability of 10,500 thirty-second full-load discharges or 300 (15) fifteen minute full-load discharges over its life. The positive plates shall be at least 0.2 inches thick.
2. One storage battery set per module shall be furnished with sufficient kilowatt hour rating to maintain the module rated output for the specified duration at 77°F and with a minimum end cell voltage of 1.67 V. Containers shall be vented and shall be made of transparent, flame retarding polycarbonate, with oxygen index of 25.0 designed for auxiliary power service. Batteries shall be equipped with flame retarding covers. Maximum specific gravity of the electrolyte shall be 1.215 ± 10 points at

77°F. All battery interconnection hardware shall be of high strength stainless steel. Terminal posts shall have copper inserts on larger cells if such inserts are manufactured for the proposed cell. Batteries shall be equipped with removable safety vents.

3. The batteries shall be lead calcium flat plate type repetitively manufactured for this type service, with 2.25 to 2.30 volts/cell float voltage.
4. The batteries shall have a design life of at least 20 years and shall be guaranteed by the battery manufacturer.
5. During formation charge of the cells, the Vender shall warranty that no posts or jar covers are stressed due to misalignment of the cells in the formation tanks. If found, cells/jars shall be replaced.
6. The battery manufacturer shall be capable of providing installation of the battery system. This includes activities to off-load, set in place, and erect: battery racks, then bolt to the floor; install spill containment system; install batteries; install inter-cell if applicable, inter-battery connectors, and inter-tier cabling up to the battery disconnect switch; and torque bolts as directed by Manufacturer, without post distortion; apply battery numbering system; install matting, mount hydrometer and thermometer, and safety kit.
7. Reserved.
8. Battery terminal parts shall be copper reinforced, with lead coating uniform over copper insert with no possibility of acid contact with the copper. Copper inserted terminal posts shall be suitable for bolted connections, with no copper exposed within the bolt-holes.
9. Where multi-cell jars/batteries are used, each individual cell shall have its posts brought through jar cover, with individual mechanical bolted connections to connecting straps. Factory “burned” cell interconnections will not be permitted.
10. Plate supports shall be so designed that anticipated positive plate growth will not stress the posts or the enclosing case. In addition, supports shall be so designed as to positively support the plates during shipment, handling and seismic stressing after final battery installation.
11. Positive and negative plates shall be independently supported from enclosing case and shall not rely on battery posts for support.
12. Distance from bottom of battery case to bottom of negative plates shall be adequate to accommodate shed plate material and to prevent negative plate shorting.
13. The jar shall have adequate space between plates and jar front and sides to permit plate growth from intruding into the jar material and deforming the jar.
14. Jar shall be marked on all four sides for observing electrolyte levels.
15. Post seals design shall be such to prevent acid migration and post corrosion.
16. The following shall be furnished with the battery string:
    a) Batteries.
    b) Battery Rack.
    c) Solid lead coated copper bus inter-cell connectors.
    d) Tier-to-tier and jar-to-jar connection materials including cables. Cables to be independently supported

e) Terminal lugs and terminal plates
f) Portable hydrometer and wall mount holder
g) Thermometer (portable or vent mounted)
h) Battery/jar numbering set
i) Battery/jar lifting strap and spreader block
j) Flame arrestor vent caps for all cells.

17. All connecting cables shall be Type W, extra flexible insulated copper conductors with solder type lugs, very conservatively sized.
18. All bolts and nuts shall be stainless steel.
19. Provide flame resistant Styrofoam or PVC spacers between battery jars.
20. Provide continuous linear insulated covers over all cell posts and inter-jar connectors
21. Identify each cell, within a jar/battery with battery/jar number and cell number.

2.13.2.3 Batteries, Battery Rack/Cabinet/Accessories. Components are batteries, battery rack/cabinet, DC Disconnect, battery circuit breaker, and accessories.

a. Provide a positive means of isolating the battery unit from the UPS power system.
   1) DC Disconnect Breaker: Mounted in or on VRLA battery rack or on the wall.
   2) Battery Circuit Breaker: Mounted on wall in FCB room. Each module shall be supplied with a 600VDC insulated case three-pole circuit breaker mounted in a UL 891 listed switchboard enclosure. The short circuit rating shall be coordinated with the battery manufacturer. Each circuit breaker shall be supplied with two form “C” contacts to indicate open and closed position and a form “C” bell alarm contact to indicate a fault trip for remote monitoring at the module. The battery circuit breaker shall be equipped with UV release.

b. VRLA Battery Rack enclosure assembly: Free-standing open frame that allows ease of maintenance without down time during battery maintenance, and free circulation of air by convection. Designed for easy and safe access to the battery terminals. Rack may have roll out drawers, using roller bearings, with drawer stops, to access battery terminals. Or, use battery racks with batteries with front mount terminals facilitating battery maintenance. If the battery rack is a drawer design the drawers shall incorporate a cable management system for power cables and battery monitor cables; and allow full and clear access to all battery terminals when the drawer is extended. Both type racks must have the option of being installed with backside against a wall.

c. FCB Battery rack shall be two (2) tier construction in height with acid resistant painted vertical and horizontal structural members and with front/rear side rails and with cross bracing between each set of vertical supports. Horizontal members on whom batteries are mounted shall be provided with an insulated mat. Construction of the racks shall be suitable for zone 4 seismic. Maximum linear length of each string shall not exceed 45-feet total and the maximum depth shall not exceed 24-inches.

d. FCB Spill Containment System. Provide an electrolyte spill containment system for installation under the FCB racks that does not require floor

preparation, treatment, or modification before installation. Spill containment provided with flame retardant self-neutralizing pillows.

e. FCB Aisle matting made of acid resistant and insulating material. The mat shall be of sufficient length to be greater than the length of the racks and a minimum of 32.5 inches wide. Bid quantity is by the linear foot. A beveled edge shall be supplied on both ends.

f. FCB Spill cleanup and disposal kit. Provide the following accessory to meet the spill containment requirements of the 1991 UBC. Spill cleanup and disposal kit shall be provided to allow clean-up after a spill. The kit shall include 20-gallon container, 10 pounds of electrolyte neutralizer, pH test strips, acid resistant gloves, sponge, and complete instructions for proper disposal of used material.

g. Tool Kit. Battery maintenance tool kit with insulated handles, and non-metallic flashlight for use in explosive gas environments.

h. Infrared Temperature Gun. Non-contact laser guided infrared temperature gun.

i. FCB Safety Kit. Wall mounted personnel safety kit to include at least the following items.

1) Eye wash bottle.
2) Apron.
3) Rubber gloves.
4) Splash Goggles.

2.13.3 Battery Monitor. (Optional Equipment) The battery monitors shall be intrinsically simple to operate, shall not require any operator hardware or software training course. Monitor display shall be included with the monitoring hardware. If monitor displays all the values on a screen the screen shall be considered part of the battery monitor and physically attached to the monitor hardware. (Separate computer or laptop displays are not desired; because the display is not part of the monitoring hardware). Simple digital displays with up and down function buttons, to display individual battery monitoring parameters, one-at-a-time, are acceptable. Since physical wire connections to the battery monitor are limited it is permitted to use more than one battery monitor/display for an UPS string of FCB.

a. Battery Monitor, Voltage: A battery rack and/or wall mount battery monitor capable of monitoring DC voltage of individual VRLA batteries and FCB batteries.

(1) Monitor shall include a display, accuracy to one hundredth of a volt (00.00), permitting readings from all batteries or cells without changing battery connections to the monitoring device.
(2) Monitor shall be capable of monitoring at least 40 individual VRLA batteries/cells and 80 individual FCB batteries.
(3) Monitor shall be capable reading 12, 6, or 2 volt batteries.

b. Battery Monitor, Voltage/Internal Resistance/Impedance/Conductance: A battery rack and/or wall mount battery monitor capable of monitoring DC voltage, and internal resistance, impedance, or conductance of individual VRLA batteries and FCB cells/units.

(1) Monitor shall include a display, accuracy to one hundredth of a volt (00.00), permitting readings from all batteries or cells without changing battery connections to the monitoring device.

(2) Monitor shall be capable of monitoring at least 40 individual VRLA batteries/cells and 80 individual FCB batteries.
(3) Monitor shall be capable reading 12, 6, or 2 volt batteries.
(4) Monitor shall have a temperature sensor for either room or cabinet ambient air temperature; and a pilot cell temperature sensor.
(5) Monitor shall be capable of reading internal battery resistance, impedance or conductance of individual batteries or cells without changing battery connections to the meter.

2.13.4 Battery Maintenance Lift. Foot operated hydraulic pump platform lift. Steel construction, two lift capacities.

a. Light-Duty Lift. Four wheeled lift with: minimum lift height of 54-inches; platform dimensions approximately 22-inches by 22-inches; 750 pound lift capacity; unit weight approximately 160 pounds. WESCO model number DPL-54-2222 or equivalent.

b. Medium-Duty Lift. Four wheeled lift with: minimum lift height of 68-inches; platform dimensions approximately 24-inches by 24-inches; 1,000 pound lift capacity; unit weight approximately 240 pounds. WESCO model number SPL-68-2424 or equivalent

2.13.5 Remote Monitor Alarm Panel. Remote annunciation panel installed within 500-feet of the UPS and hardwired to the UPS . These are dry contact points. This is console or wall mount panel indicating basic UPS functions. Terminology for the five status lights will vary from vender to vender regardless of the labeling they should represent the terminology listed below.

a. UPS on/Load on Inverter/Normal Operation/System Normal.
b. Load on Bypass/Static bypass Operation.
c. UPS on Battery Operation
d. Battery Low/Battery low voltage
e. UPS Failure/UPS off

2.13.6 Load Bank. Permanently installed resistive load Banks are completely self-contained, freestanding units which include all resistive load elements, load control devices, load element branch circuit fuse protection, main load bus and terminals, cooling system, control power supply, for use with load testing 208 and 480 volt UPS units. Designed for outdoor operation; mounted in enclosures equipped with screened and louvered intake and exhaust openings to protect against debris.

2.14 Enclosure and Electrical Components General Requirements

2.14.1 General Requirements

2.14.1.1 All materials and parts comprising the UPS system shall be new, of current manufacturer, of a high grade, free from all defects or imperfections, and shall not have been in prior service, except as required during factory testing.

2.14.1.2 All active electronic devices shall be solid-state. All semiconductor devices shall be hermetically sealed. Vacuum tubes shall not be used for any purpose. All relays shall be dust tight. All capacitors shall be non-PCB type and fused by group or individual fuses.

2.14.1.3 A minimum of 25 degrees C operating margin from the maximum allowable junction temperature shall be provided for all solid-state semiconductor devices.

2.14.1.4 Modularity: The UPS system solid-state power switching circuits and control systems shall be modular in construction for ease of maintenance and to minimize downtime. The modules shall be grouped by function with interchangeability between any modules that have the same function. All solid-state power switching modules shall be removable from the front of the UPS system. The UPS system shall be designed to permit ready access to modules and assemblies.

2.14.1.5 Printed Circuit Boards: All plug-in printed circuit boards shall have mechanical interlocks to prohibit a board from being plugged into the wrong place and electrical interlocks to prohibit system operation if all boards are not properly installed.

2.14.1.6 Cable Access: All power and control connections to the UPS module shall be made possible via top and bottom access. Adequate conduit entry space and cable bending space shall be provided for the full complement of wiring as required by input and output circuit breaker amperage ratings.

2.14.1.7 Surge Protection: The UPS system shall have built-in protection against under voltage, overcurrent, and over voltage, including lightning surges introduced on the primary AC source and voltage and current surges on the output caused by load transfer between itself and an external synchronized source. If MOV's are used, proper upstream protection and adequate physical shielding shall be utilized in order to prevent a catastrophic failure of the MOV to propagate throughout the module and cause the system failure.

2.14.2 Mechanical Enclosure Design

2.14.2.1 Three-Phase Enclosures: The UPS shall be housed in a freestanding enclosure. The enclosure shall be designed for fork truck lifting. All service access and field wiring terminations shall be from the front.

2.14.2.1.1 UPS module dimensions, for all input and output voltages:

a. Height: Maximum 84".
b. Width:
    30 - 39 KVA Maximum 60"
    40 – 49 KVA Maximum 68"

50 – 65 KVA Maximum 68”
66 – 80 KVA Maximum 68”
80 - 100 KVA Maximum 73”
101 - 150 KVA Maximum 81”
151 – 250 KVA Maximum 83”
251 - 300 KVA Maximum 83”
301 – 400 KVA Maximum 83”
500 KVA Maximum 115”

c. Depth: Maximum 32” for all KVA ranges.

2.14.2.1.2 UPS VRLA Battery rack or cabinet dimensions:

a. Height: Maximum 84” for fixed frame racks for all KVA ranges.
b. Width:

30 -39 KVA Maximum 36”
40 – 49 KVA Maximum 36”
50 – 65 KVA Maximum 60”
66 – 80 KVA Maximum 60”
81 - 100 KVA Maximum 120”
101 - 150 KVA Maximum 120”
151 – 250 225 KVA Maximum 120”
251 - 300 KVA Maximum 250”
301 – 400 KVA Maximum 250”
500 KVA Maximum 250”

c. Depth: Maximum 32” for all KVA ranges.

2.14.2.1.3 Manual Maintenance Bypass cabinet, floor mount.

a. Height: Maximum 84”.
b. Width:

30 – 39 KVA Maximum 34”
40 – 49 KVA Maximum 34”
50 – 65 KVA Maximum 34”
66 – 80 KVA Maximum 34”
81 - 100 KVA Maximum 34”
101 - 150 KVA Maximum 34”
151 – 250 KVA Maximum 49”
151 - 300 KVA Maximum 49”
301 – 400 KVA MAXIMUM 49”
500 KVA Maximum 49”

c. Depth: Maximum 32” for all KVA ranges

2.14.2.1.4 Manual Maintenance Bypass cabinet, wall mount.

a. Height: Maximum 84”.
b. Width:

30 – 39 KVA Maximum 34”
40 – 49 KVA Maximum 34”
50 – 65 KVA Maximum 34”
66 – 80 KVA Maximum 34”
81 - 100 KVA Maximum 34”
101 - 150 KVA Maximum 34”
151 – 250 KVA Maximum 49”

151 - 300 KVA Maximum 49”
301 – 400 KVA MAXIMUM 49”
500 KVA Maximum 49”

c. Depth: Maximum 32” for all KVA ranges

2.14.2.2 Ventilation: The UPS shall be cooled by free air ventilation or by forced air ventilation. If forced air is used then fan-monitoring circuitry shall be utilized. External battery systems shall be cooled by free-air ventilation and convection.

2.14.2.3 Seismic Mounting: All cabinets and racks shall provide International Building Code 2000 (IBC 2000) Zone 4 seismic mounting features.

2.14.2.4 The UPS system assemblies shall be constructed in modular units, installed in NEMA Type-1 metal enclosures.

2.14.2.5 Pull-out drawers shall be connected by quick disconnect fittings. Components not mounted in pullout drawers shall be firmly mounted inside the enclosures. Test points or terminals for maintenance shall be readily accessible and marked.

2.14.2.6 The UPS individual enclosures shall be free standing, capable of side-by-side or back-to-back installation with front access requirements only.

Part 3 Equipment Start-up and Testing

3.1 UPS Start-Up Service

The UPS vender provides start-up service. The installation contractor is responsible for providing all labor and material to commission the UPS system. The start-up service, at a minimum, shall do the following tasks.

- Record UPS unit make/model and serial number for factory warranty documentation.
- Validate the installation integrity of the UPS unit and battery electrical connections.
    1. Check essential panel UPS circuit breakers, maintenance bypass breaker;
    2. Verify manual maintenance bypass cabinet configuration;
    3. Critical panel main breaker;
    4. Load bank connections; and
    5. UPS input and output power connections.
- Perform a full mechanical inspection of the unit.
- Start UPS unit.
- Configure UPS unit’s programmable settings.
    1. Reset or verify correct factory programmed settings;
    2. Set proper battery charge and float voltages; and
    3. Record all UPS parameter settings give this document to FAA.
- Verify that all operating and monitoring parameters are functioning.
- Provide at least two (2) hours of basic operator training.
    1. Instruct on use of UPS menu screen;
    2. Transfer to static bypass and back again,

3. Remove UPS from critical load without power interruption, using the manual maintenance bypass cabinet.

3.2 UPS System Test.

The UPS Vender technician shall be on site for the duration of the test to record system parameters and ensure that the system functions as specified. The UPS Vender shall perform all UPS system tests, including batteries, disconnecting devices, and manual maintenance bypass function as needed to certify the proper operation of the system as a whole. A recommended UPS system test procedure shall be provided by the UPS system Vender and approved by the Government.

a. UPS start-up must be completed before beginning system test.
b. The UPS system Vender shall provide all testing and monitoring equipment required to conduct these site tests.
c. The Installing Contractor shall provide electricians for all tests.
d. Load banks and load bank cables as required for site testing shall be provided and operated by the Installing Contractor.

3.2.1 UPS Test

3.2.1.1 UPS-Module

a. UPS Data
   1) Make:_____ Model: _____
   2) Serial #: _____ kVA: _____ kW:_____
b. Battery Data_
   1) Make:_____ Model: _____
   2) # of Strings: _____ Jars/string: _____ Cells/Jar: _____ Float/Cell: _____

3.2.1.2 Heat Run.

Operate the entire system continuously for four (4) hours at full load. Record the system output voltage, current and frequency on each phase at one hour time intervals to verify stability of the UPS output. Also monitor and record the room temperature throughout the heat run. After 4-hours, perform an infrared scan of UPS module(s) and UPS input and output breaker.

3.2.1.3 Steady-State Load Tests

1. Connect the three phase multi-functional Power Quality Meter (PQM) to the input of the UPS module to be tested.
2. Record the three phase input voltage, current, power, Power Factor, and total harmonic distortion (voltage and current distortion) with the RPM recorder. Record, on the data sheets, the three phase input voltage and current readings from the PQM recorder and from the UPS front panel at the following load levels:
   a) 100% load.
   b) 50% load.
   c) No load (0% load).
3. Connect the PQM recorder to the output of the UPS module to be tested.
4. Record three-phase output voltage, current, power, pF, and total harmonic distortion (voltage and current distortion) with the PQM. Record, on the attached data sheets, three phase output voltage and current readings from the PQM recorder and from the UPS front panel at the following load levels:
   a) 100% load.

b) 50% load.
c) No load (0% load).

5. While 100% load is applied to the unit record the following on the attached data pages:
   a) Three phase current into the input filter.
   b) Three phase current into the output filter.
   c) Three phase current into the rectifier(s).

3.2.1.4 Transient Load Tests

1. Connect the Waveform Recorder to the output of the UPS module to measure three phases of output voltage, and one phase of output current.
2. Record the following load step transients with the waveform recorder:
   a) 0% - 50% - 0%.
   b) 50% - 100% - 50%.
   c) 25% - 75% - 25%.
3. Connect the PQM waveform recorder to measure three phases of output voltage and one phase current of the bypass input.
4. Record the following transfer transients with the waveform recorder:
   a) Normal transfer to bypass with 100% load applied.
   b) Module failure to bypass with 100% load applied.
   c) Move the waveform recorder current transformer to the modules input. Transfer from bypass to UPS with 100% load applied.

3.2.1.5 Battery Discharge Test

1. Verify that the UPS Module's low battery shutdown voltage setting is set to the level above battery manufacturer's end of discharge voltage criteria.
2. Connect the Waveform recorder to measure three phases of output voltage and one phase of input current.
3. Verify that the PQM is connected to the output of the UPS module. Set the PQM to monitor mode.
4. Connect a multi-meter to measure the mV drop across the DC shunt of the UPS module. Record the mV/amp ratio on the battery discharge data sheet.
5. Connect another multi-meter to measure the DC bus voltage.
6. Verify that 100% load is applied to the UPS module.
7. Send the UPS module to battery. Record the following:

a) The initial transfer to battery with the waveform recorder.
b) DC bus voltage and current from the UPS front panel
c) DC bus voltage and DC shunt mV from the Fluke multi-meters
d) Infrared scan the batteries during battery discharge.

8. End the battery discharge test when either the battery manufacturers end of discharge voltage is reached, or the UPS manufacturers low battery shutdown voltage is reached (whichever occurs first).
9. Record the utility restoration and rectifier ramp with the waveform recorder.

3.2.1.6 Infrared Scan

1. Infrared scan the entire UPS module after 100% load has been applied for a minimum of 15 minutes.

2. Infrared scan all UPS batteries and battery connections during battery discharge.
3. Infrared scan all UPS batteries during battery recharge for approximately 5 minutes.
4. Transfer the UPS module to internal bypass and infrared scan the internal bypass path once full load has been applied for a minimum of 15 minutes.
5. Transfer the UPS module to Maintenance bypass and infrared scan the load side of the Maintenance bypass cabinet once full load has been applied for a minimum of 15 minutes.

3.2.2 System Test

A recommended system test procedure shall be submitted to the Government for review and approval. Testing shall use the facility load bank.

3.2.2.1 As a minimum the following system tests are required.

1. Verify that all operating controls, alarms, meters and mimic lights are functioning properly.
2. Verify that all alarms function properly. Record all trip points either by simulation or actual fault condition. Indicate on documented procedure which faults were conducted by which means.
3. Verify all functions including all transfer capabilities.
4. Voltage regulation. Record L-L voltage for each module and for system.
   a) Record each system output voltage at no load.
   b) Record each system output voltage at half rated load.
   c) Record each system output voltages at full rated load.
   d) Calculate the voltage regulation as follows:
      1) (L-NL)/NL)x100=%Voltage regulation
      2) NL= No load volts
      3) L = 1/2 or full rated load volts
5. Transient Tests
   a) A light beam recorder or equivalent shall be utilized with sufficient bandwidth to record one cycle of a 1000 Hertz sine wave and with sufficient channels to monitor three phase voltage output, single phase current output, single phase current input and single phase voltage input.
   b) Record all system level voltages, current, kW and pf for both, input and output of steady state load steps prior to conducting test.
      Example: Step load from 25% to 75%. Record the 25% load setting and the 75% load setting before performing the transient test.
   c) Each transient test listed below shall be recorded and shall meet the following criteria, except when noted otherwise:
   d) Plus 8% or minus 8% with a recovery of 16 milliseconds to within plus or minus one percent of the initial steady state value. Each individual transient, measured line to line shall meet these criteria.
   e) The method of measuring a transient is as follows:
   f) The steady state voltage envelope prior to the transient measured in millimeters is subtracted from the peak-to-peak transient measured in millimeters. This absolute difference is divided by the steady state

voltage envelope and multiplied by 100 to arrive at the percent transient.

g) An interruption of power under any of the following transient tests are considered to be out of spec:

1) Load Step Transients:

a. For each module, perform the following load steps:

(1) 0% to 50% to 0% of the full module load
(2) 25% to 75% to 25% of the full module load
(3) 50% to 100% to 50% of the full module load
(4) 75% to 110% to 75% of the full module load
(5) 0% to 100% to 0% of the full module load

2) UPS to Bypass Transfer Transients

a. With the entire system operating at full load, transfer the load from the UPS to the bypass and back to UPS.

3) Isolation Transients: With the entire system operating at full load, simulate a blown fuse in one module. Observe the module removing itself from the output bus.

4) Input Fail Transient: This test is to be conducted with a fully charged battery, with module on-line and at full rated load. The system output voltage shall be monitored by the light beam recorder.

5) Note that the transients do not exceed the Specification or that the output modulation of each module does not exceed 1% as defined by the formula below:

$$VM\% = \frac{(Ep\ MAX - Ep\ MIN) \times 100}{Ep\ MAX + Ep\ MIN}$$

EpMAX = Maximum phase voltage (peak-to-peak)
EpMIN = Minimum phase voltage (peak-to-peak)

a. Remove the input power for one minute and then re-energize.

b. Repeat this test a total of three times to demonstrate consistency in performance.

6) Loss of Bypass Remove the bypass line from the system input for 3 minutes. Reconnect the bypass and record the time until the UPS system synchronizes to bypass.

6. System Battery Tests: The objective of this test is to verify the compatibility of the batteries with the associated UPS system and to verify the full load operation of each module for the reserve time and to cut off voltage specified.

a) Prior to the start of the test, the battery shall be floated at the required voltage for the time specified by the battery vender. Measure and record the resistance of all inter-cell and inter-tier connections using a micro-ohmmeter.

b) UPS module is tested using the facility UPS load bank to a cut off voltage of 1.67 volts/cell after UPS rectifier input circuit breaker is opened and the UPS inverter is connected to the load bank.

c) After successfully battery load test, recharge batteries of system to 95% capacity, after which time perform system tests as specified.

d) The test shall be conducted with each UPS module at the specified load. Remove the AC input and record the time and measure and record voltage drop across each battery connection under full load.

At thirty seconds intervals, record the DC voltage and current. Record the time in which the battery discharge related alarm occurs and conduct an infrared scan of the battery installation. Using the light beam recorder running at slow speed, record the critical load voltage and one phase input current prior to and during the entire input fail. Continue to record without interruption for a minimum of five minutes to demonstrate the input walk-in current and the input current limit.

e) After successful completion of individual module testing, perform the following system tests at full load using a light beam recorder connected across system output.
   1) Open utility input breaker, record output voltage and current during input failure when inverter input transfers from rectifier to battery.
   2) Close utility input breaker, record output voltage and current during time when inverter input transfer from battery to rectifier.
   3) Failed UPS system, critical load transfers to UPS static by-pass utility input, record voltage and current during time, load transfers between inverter output and utility.
   4) Reestablish UPS system output, critical load transfers from UPS static by-pass to UPS output, record voltage and current during time, load transfers between static switch and inverter output.
f) The batteries shall be recharged to 95% of full charge within 12 times the discharge time. Record every thirty minutes the input and output voltage, current, kW, pf, frequency and the DC voltage and current until the recharge requirement is met.
g) Upon successful completion of the battery tests and after the batteries have a chance to reach their normal charge and temperature, take a full set of cell voltage readings, specific gravity and cell temperature readings.
h) After completion of discharge testing, torque connections varying by more than ±10% of average voltage.
i) After completion of installation and acceptance of system by the Government, Vender shall certify that installation is complete and in accordance with all of Venders requirements and that Vender warrantee is in effect.

3.2.2.2 An integral power system test designed to demonstrate the operation of the UPS system in conjunction with the emergency generator(s) shall also be conducted by the Contractor with assistance of the Vender. The test shall extend for at least four hours and shall prove the following:

1. Compatibility between the UPS system and the generators, i.e. harmonics will not influence voltage regulation and the UPS input filter will not affect the generator(s).
2. Ability of the UPS system to synchronize to the generator output.
3. Ability of the UPS system to bypass the UPS unit using the manual maintenance bypass cabinet and back while essential buss is powered from the generator(s).
4. Ability of the UPS to limit battery recharge current while on generator(s) power.

3.3 FACTORY WITNESS TEST

The Vender shall perform all tests on an UPS unit as required to verify the proper operation of each component. A recommended factory witness test procedure shall be provided by the UPS system Vender and approved by the Government. There shall be no additional cost to the Government for the Government's representative to witness the UPS system factory test.

Someone different than the person responsible for the original code or any subsequent changes shall test all functions on a software simulator. Proper functioning of the software shall be demonstrated on a simulator. The factory witness testing program shall be designed to test multiple combinations of variables, particularly those that will be difficult to test in the field.

As a minimum, the following factory tests are required for each UPS unit:

1. Verify that all operating controls, alarms, meters and mimic lights are functioning properly.
2. Verify that all alarms function properly. Record all trip points either by simulation or actual condition. Indicate on the test procedure which faults were conducted by which means.
3. Primary and secondary injection testing of all circuit breakers.
4. Operate each system in both linear and non-linear modes (i.e.; 33% 3^{rd} harmonic, 20% 5^{th} harmonic, 15% 7^{th} harmonic, 11% 9^{th} harmonic 8% 13^{th} harmonic, 7% 15^{th} harmonic, 6% 17^{th} harmonic, 5% 19^{th} harmonic) having a crest factor of 3:1, at no load, 50% and 100% resistive load and at .8 power factor reactive load. Record the following data:
   a. Input voltage line to line and line to neutral
   b. Input current
   c. Input frequency
   d. Input kW
   e. Output voltage line to line and line to neutral
   f. Output current
   g. Output frequency
   h. Output kW

5. The system shall undergo load regulation, power converter load sharing, efficiency and harmonic tests with loads as listed above and below.

6. Voltage Regulation. Record L-L voltage for each module and for system.

   a. Record each system output voltage at no load.
   b. Record each system output voltage at half rated load.
   c. Record each system output voltage at full rated load.
   d. Calculate the voltage regulation as follows:
      1) (L-NL)/NL)x100=%Voltage regulation
      2) NL = No load volts
      3) L = Half or full rated load volts

7. Unbalanced Load Tests

a. Record each system output voltage both line to line and line to neutral with 80% load on Phase A, 100% load on Phase B and 80% load on Phase C.
b. Record each system output voltage both line to line and line to neutral with 50% load on Phase A, 100% load on Phase B and 50% load on Phase C.

c. Calculate the voltage unbalance as follows:

1) $\frac{(V_{max} - V_{min}) \times 100}{} = \%$ Balance

d. Calculate the phase angle unbalance as follows:
1) Cosine Phase A = $\frac{(B\ L\text{-}N)^2 + (C\ L\text{-}N)^2 + (BC\ L\text{-}L)^2}{(B\ L\text{-}N)\ (C\ L\text{-}N)}$
2) Phase angle of A = Arc Cosine Phase A
3) Cosine Phase B = $\frac{(C\ L\text{-}N)^2 + (A\ L\text{-}N)^2 - (CA\ L\text{-}L)^2}{(C\ L\text{-}N)\ (A\ L\text{-}N)}$
4) Phase angle of B = Arc Cosine Phase B
5) Cosine Phase C = $\frac{(A\ L\text{-}N)^2 + (B\ L\text{-}N)^2 - (AB\ L\text{-}L)^2}{(C\ L\text{-}N)\ (A\ L\text{-}N)}$
6) Phase angle of C = Arc Cosine Phase C

8. Efficiency
a. System efficiency shall be measured at load levels listed without batteries connected. Perform the efficiency tests immediately following the heat run called for hereinafter and without interruption between the heat run and the efficiency tests. Record for each system.
1) Full Load
2) 75% Load
3) 66% Load
4) 50% Load
5) 25% Load
6) No Load Losses

The efficiency shall be calculated as follows:

- % System Efficiency = $\frac{\text{System output (kW)}}{\text{System input (kW)}}$

9. Harmonic Distortion Test: At the various load levels listed below, record the total input current harmonic and the total output voltage harmonic on each phase, line-to-line. Record for each system.
a. No Load
b. 25% Load
c. 50% Load
d. 75% Load
e. 100% Load

10. Transient Tests
a. A light beam recorder or equivalent instrument shall be utilized with sufficient bandwidth to record one cycle of a 1000 Hertz sine wave

and with sufficient channels to monitor three phase voltage output, single phase current output, single phase current input and single phase voltage input.

b. Record all system level voltages, current, kW and pf for both, input and output of the steady state load steps prior to conducting test. Example: Step load from 25% to 75%. Record the 25% load setting and the 75% load setting before performing the transient test.

c. Each transient test listed below shall be recorded and shall meet the following criteria, except when noted otherwise: Plus 8% or minus 8% with a recovery of 16 milliseconds to within plus or minus one percent of the initial steady state value. This criteria shall be met by each individual transient, measured line-to-line.

d. The method of measuring a transient is as follows:
   1) The steady state voltage envelope prior to the transient measured in millimeters is subtracted from the peak-to-peak transient measured in millimeters. The absolute difference is divided by the steady state voltage envelope and multiplied by 100 to arrive at the percent transient.
   2) An interruption of power under any of the following transient tests are considered to be out of spec:

e. Load Step Transients: For each module, perform the following load steps:
   1) 0 to 50% to 0 of the full load
   2) 25% to 75% to 25% of the full load
   3) 50% to 100% to 50% of the full load
   4) 75% to 110% to 75% of the full load
   5) 0% to 100% to 0% of the full load

f. UPS to Bypass Transfer Transients: With the entire system operating at full load, transfer the load from the UPS to the bypass and back to UPS.

g. Input Fail Transient: With the maximum practical load based on plant battery, and all modules on-line, record system output transients while rapidly opening and re-applying input voltage at least five times in succession. Observe that no malfunctions occur.

h. Operation without Batteries: Demonstrate at full load that the system will operate without batteries by opening all battery disconnect switches and recording any output disturbance. Continue operation in this mode for five minutes.

i. Loss of Bypass: Remove the bypass line from the system input for 3 minutes. Reconnect the bypass and record the time until the UPS system synchronizes to bypass.

j. Short Circuit Test: At full load, perform a direct output short circuit from phase to phase. Record on a light beam recorder the output current envelope. Calibrate the current trace so that the maximum current can be established.

11. DC Ripple: With the battery disconnected, and with the module operating at full load, measure the ripple across the DC bus and verify that it does not exceed 1%.
    a. VR% = VAC (RMS)/VDC
    b. VAC (RMS) = maximum RMS voltage, measured across the DC bus
    c. VDC = DC bus voltage

12. Logic power Supply Failure Test

    a. With the system operating at full load, simulate the simultaneous failure of the logic power supplies in each UPS module. Verify that the module shuts down without affecting the system output bus.
    b. Simulate the simultaneous failure of the logic power supplies in the system cabinet and insure that the system continues to operate without any degradation of the output voltage waveform.

13. Overload Test: The UPS system shall be operated for a least 5 minutes under full load. Load shall then be increased to 125% full load, held for two minutes and returned to normal. Load shall then be increased to 150% full load, held for sixty seconds and returned to normal. The input, DC and output current protection devices shall not trip or otherwise activate during this test. The UPS system output voltage shall remain within specified tolerance. The internal bypass circuits shall be inhibited during this test. Record output voltage regulation for each test.
14. Shorted SCR Alarm Verification: With the system operating at full load, short out a Static Switch SCR and verify that the shorted SCR alarm is activated. Repeat for each phase.
15. 100% Rated Static Switch Testing: With the system operating at full load, transfer the system to static switch bypass and open the static switch wraparound bypass circuit breaker. Run system in this configuration for a minimum of one hour.
16. Short Circuit Test: With the entire system operating at full load, create a ground fault at the inverter output of a module. Monitor the UPS system output and insure that the output voltage transient does not exceed the specified limits.
17. Burn-In Test:
    a. The UPS system shall be run at a minimum of 24 hours at full load and an ambient room temperature of approximately 77 degrees F. If the test is interrupted for any reason including component failure, or if the equipment does not meet the requirements of the Specifications, the entire test shall be repeated after the defects have been corrected. Once started, load test must be run continuously with temperature and electrical data logged every 30 minutes.
    b. Each module shall be run with thermocouple measurement devices attached for a minimum of 24 hours at full load and rated power factor (500 kVA) at an ambient room temperature of approximately 77 degrees F
    c. Heat run shall include monitoring of component temperature of the following throughout the heat run procedure:
        1) Ambient
        2) Rectifier intake
        3) Lead inverter blower intake
        4) Lag blower intake
        5) Lag inverter Phase A heat sink
        6) Lag inverter Phase B heat sink
        7) Lag inverter Phase C heat sink
        8) Lead inverter Phase A heat sink
        9) Lead inverter Phase B heat sink
        10) Lead inverter Phase C heat sink

11) Rectifier wye assembly heat sink
12) Rectifier delta assembly heat sink
13) Input transformer Phase B coil
14) Output transformer Phase B coil

18. System Battery Tests: The exact performance of this test will depend upon the capability of the UPS manufacturer's in-plant test battery. However, the following tests shall be performed as a minimum. A detailed procedure submitted by UPS manufacturer shall provide an accurate step-by-step test:
    a. Run each module on battery as close as possible to full load specified battery end voltage.
    b. During and after above test, provide continuous recording of output voltage and one phase of input current to record complete cycle of input fail, input return and power walk-in.

19. Synchronizing Circuit: The operation of the synchronizing circuits shall be demonstrated during the factory test in accordance with submitted/approved testing plan.