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USACE / NAVFAC / AFCESA / NASA	**UFGS-26 32 33.00 10 (April 2004)**
Preparing Activity: USACE	**Replacing without change UFGS-16265A (December 2004)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 1 April 2006

Latest change indicated by CHG tags
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DIVISION 26 - ELECTRICAL

SECTION 26 32 33.00 10

UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM ABOVE 15 KVA CAPACITY

04/06

-- End of Section Table of Contents --

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SECTION 26 32 33.00 10

UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM ABOVE 15 KVA CAPACITY
04/06

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NOTE: This guide specification covers the requirements for static UPS to provide continuous ac power to critical loads and/or to improve the quality of ac power to critical loads.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update

the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 173	(2001a) Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.110	(1998) Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents
IEEE C62.41	(1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 450	(2002) Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
IEEE Std 485	(1997) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA PE 1	(2003) Uninterruptible Power Systems -- Specification and Performance Verification

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

1.2 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not

complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

UPS System
Installation

Detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations per IEEE Std 485, installation instructions, single-line diagrams, ladder-type schematic diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit.

SD-03 Product Data

Performance Requirements

Pertinent performance data for the UPS system, using a copy of the data sheets supplied with this specification. Data sheets shall be certified by a responsible officer of the UPS manufacturer.

Spare Parts

Spare parts data, as specified.

Field Training[; G][; G, [_____]]

Lesson plans and training manuals for the training phases,

including type of training to be provided and proposed dates, with a list of reference materials.

SD-06 Test Reports

Factory Testing
Field Supervision, Startup and Testing

A detailed description of proposed factory test and field test procedures, including proposed dates and steps outlining each test, how it is to be performed, what it accomplishes, and its duration, not later than [_____] months prior to the date of each test.

Factory and field test reports in booklet form tabulating factory and field tests and measurements performed, upon completion and testing of the installed system. Factory and field test reports shall be signed by an official authorized to certify on behalf of the manufacturer of the UPS system that the system meets specified requirements. The reports shall be dated after the award of this contract, shall state the Contractor's name and address, shall name the project and location, and shall list the specific requirements which are being certified.

1.3 SYSTEM DESCRIPTION

****
NOTE: Delete system cabinet when specifying a single module UPS system.
****

The UPS system shall consist of UPS module, battery system, battery protective device, system cabinet, static bypass transfer switch, controls and monitoring. Input ac power shall be connected to the normal source ac input of the UPS module. The battery shall be connected to the dc input of the UPS module through the battery protective device. The ac output of the UPS system shall be connected to the critical loads.

1.3.1 UPS Module and Battery System

UPS module shall contain required input isolation transformer, rectifier/charger unit, inverter unit and controls, battery protective device, and any other specified equipment/devices. Battery system shall contain the battery cells, racks, battery disconnect, battery monitor and cabinet, if required.

1.3.2 Cabinet, Static Bypass Transfer Switch, Control and Monitoring

The UPS system shall include the system cabinet, static bypass transfer switch, system protective devices, monitoring and controls, means of isolating the system from the critical load, and remote monitoring interfaces.

1.3.3 Design Requirements

1.3.3.1 Parts and Materials

Parts and materials comprising the UPS system shall be new, of current manufacture, of a high grade and free of defects and imperfections, and

shall not have been in prior service except as required during aging and factory testing.

1.3.3.2 Components

Active electronic devices shall be solid state. Semiconductor devices shall be sealed. Relays shall be dust-tight.

1.3.3.3 Semiconductor Fusing

Power semiconductors shall be fused to prevent cascaded or sequential semiconductor failures. Indicator lamp denoting blown fuse conditions shall be readily observable by the operator without removing panels or opening cabinet doors.

1.3.3.4 Interchangeability

The subassemblies in one UPS module shall be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

1.3.3.5 Control Power

Control power shall be derived from two sources, input and output, with automatic selective control. The control power circuit shall have suitable protection, appropriately marked and located in the immediate vicinity of the input protective device.

1.3.3.6 EMI/RFI Protection

The components and the system shall be designed to minimize the emission of electromagnetic waves that may cause interference with other equipment.

1.3.3.7 Wiring

Wiring practices, materials, and coding shall be in accordance with the requirements of NFPA 70 and other applicable standards. Wire runs shall be protected in a manner which separates power and control wiring. Control wiring shall be minimum No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Ribbon cables shall be minimum No. 22 AWG. Control wiring shall have permanently attached wire numbers.

1.3.3.8 Terminations

Terminals shall be supplied for making power and control connections. Terminal blocks shall be provided for field wiring terminals. Terminal blocks shall be heavy-duty, strap-screw type. Terminal blocks for field wiring shall be located in one place in each module and in the system cabinet. Control wiring shall be extended to the terminal block location. No more than two wires shall land on any terminal point. Where control wiring is attached to the same point as power wiring, a separate terminal shall be provided. If bus duct is used, bus stubs shall be provided where bus duct enters cabinets.

1.3.3.9 Internal Assembly

The subassemblies shall be mounted in pull-out and/or swing-out trays where feasible. Cable connections to the trays shall be sufficiently long to allow easy access to all components. Where not feasible to mount

subassemblies in pull-out or swing-out trays, they shall be firmly mounted inside the enclosure. Test points or logic indicators shall be labeled and located on the front edge of the control logic cards, if used.

1.3.3.10 Cabinet Structure

UPS system shall be installed in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. UPS module cabinet shall be structurally adequate for forklift handling or lifting. Removable lifting eyes shall be provided on top of each cabinet. UPS module cabinet shall have hinged and lockable doors on the front only, with assemblies and components accessible from the front. Doors shall be key lockable. Operating controls shall be located outside the locked doors. Input, output, and battery cables shall be installed through the top or bottom of the cabinet.

1.3.3.11 Cabinet Finish

Equipment cabinet shall be cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards.

1.3.3.12 Mimic Bus

If painted, mimic bus and other front-panel markings (such as those showing circuit breakers or switches and fuses) shall be painted with durable acrylic-based paint.

1.3.3.13 Live Parts (300 Volts and Above)

Live parts (300 volts and above) that are exposed when front access doors are open shall be adequately protected or covered to minimize the chance of accidental contact.

1.3.3.14 Drawout Assemblies

Drawout assemblies weighing 23 kg 50 lbs or more shall be provided with a means of lifting, either an overhead device or a hoisting device.

1.3.3.15 Safety

UPS shall be equipped with instruction plates including warnings and cautions, suitably located, describing any special or important procedures to be followed in operating and servicing the equipment.

1.3.4 Performance Requirements

1.3.4.1 Normal Operation

The UPS module rectifier/charger shall convert the incoming ac input power to dc power for the inverter and for float charging the battery. The inverter shall supply ac power continuously. Inverter output shall be synchronized with the bypass ac power source, provided that the bypass ac power source is within the specified frequency range. The UPS system shall supply ac power to the critical loads.

1.3.4.2 Loss of ac Input Power

The battery shall supply dc power to the inverter so that there is no

interruption of ac power to the critical load whenever the ac input power source deviates from the specified tolerances or fails completely. The battery shall continue to supply power to the inverter for the specified protection time. At the same time, an alarm shall sound to alert operating personnel, allowing startup of a secondary power source or orderly shutdown of the critical load.

1.3.4.3 Return of ac Input Power Source

The rectifier/charger shall start and assume the dc load from the battery when the ac input power source returns. The rectifier/charger shall then simultaneously supply the inverter with dc power and recharge the battery. This shall be an automatic function and shall cause no disturbance to the critical load.

1.3.4.4 Failure of ac Input Power to Return

Should the ac input power fail to return before the battery voltage reaches the discharge limit, the UPS system shall disconnect from the critical load to safeguard the battery.

1.3.4.5 Failure of a Module

****
NOTE: Delete for parallel non-redundant multi-module UPS systems and single module UPS systems.
****

In a redundant configuration, failure of one module shall cause that module to be disconnected from the system critical load bus by its internal protective devices and its individual output protective device. The remaining module shall continue to carry the load. Upon restoration of the failed module, it shall be possible to reconnect the failed module to the critical load bus to resume redundant operation without disruption of the critical load.

1.3.4.6 Transfer to Bypass ac Power Source

****
NOTE: Edit as required for parallel non-redundant multi-module UPS systems or single module UPS systems.
****

When the static bypass switch senses an overload, two or more inverter shutdown signals, or degradation of the inverter output, the bypass switch shall automatically transfer the critical load from the inverter output to the bypass ac power source without an interruption of power only if the connected load exceeds the capacity of the remaining on-line modules. If the bypass ac power source is out of normal tolerance limits, the UPS and the critical load shall shut down.

1.3.4.7 Retransfer to Inverter

The static bypass switch shall be capable of automatically retransferring the load back to the inverter output after the inverter output has returned to normal conditions. Retransfer shall not occur if the two sources are not synchronized.

1.3.4.8 UPS Module Maintenance

****
NOTE: Delete for parallel non-redundant multi module UPS systems and single module UPS systems.
****

UPS modules shall be capable of manual disconnection from the critical load bus for maintenance without disturbing the critical load bus.

1.3.4.9 UPS System Maintenance

Manual closure of the maintenance bypass switch shall transfer the critical load from the inverter output to the bypass ac power source without disturbing the critical load bus. UPS module shall be capable of manual return to normal operation after completion of maintenance.

1.3.4.10 Battery Maintenance

The battery protective device shall provide the means of disconnecting the battery from the rectifier/charger and inverter for maintenance. The UPS module shall continue to function and meet the performance criteria specified except for the battery function.

1.4 QUALITY ASSURANCE

****
NOTE: Reliability and maintainability are relative terms, and the attainable level will, therefore, depend upon the type, size, configuration, and degree of redundancy of the UPS. System availability is a function of reliability and maintainability and is defined as the long-term average fraction of time that a system is satisfactorily in service. System availability should be as high as economically feasible and may be calculated as follows:

A = MTBF/(MTBF + MTTR)

Where

A = Availability

MTBF = Mean Time Between Failures

MTTR = Mean Time To Repair

Nonredundant systems can have a predicted MTBF of 20,000 hours and an actual MTBF of 40,000 hours. On the other hand, larger redundant systems or nonredundant systems with available utility power through a bypass arrangement can have an actual MTBF of 200,000 hours. A multi-module system with utility power bypass arrangement will have a higher MTBF than a single module system with the same rating.

The designer should give serious thought and consideration to the question of specifying MTBF and MTTR. For additional information on the subject refer to the following:

a. IEEE Std 446, Emergency and Standby Power Systems for Industrial and Commercial Applications.

b. IEEE Std 493, Design of Reliable Industrial and Commercial Power Systems.

c. MIL-STD 471, Maintainability Verification/ Demonstration/Evaluation.

****

1.4.1 Reliability

UPS shall have a minimum acceptable system Mean Time Between Failures (MTBF) of [_____] hours. A failure is defined as any interruption to or degradation of the UPS output. Automatic switching to bypass due to a problem with the UPS system does not constitute a failure, provided that the critical load is not disturbed.

1.4.2 Maintainability

UPS shall have a maximum acceptable system Mean Time To Repair (MTTR) of [30] [_____] minutes. Repair time is defined as the clock time from the arrival of the service technician to the time when the UPS is restored to service either by repair or substitution of the failed component.

1.5 DELIVERY AND STORAGE

Equipment placed in storage shall be protected from humidity and temperature variations, dirt, dust, or other contaminants.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Conditions

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NOTE: Designer must show approximate elevation above sea level for project location if it exceeds 1,200 meters (4,000 feet). UPS system must be derated if 50 degrees C (122 degrees F) operating temperature is required.

****

The UPS and battery system shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

a. Operating altitude: Sea level to 1,200 m 4,000 feet. (Systems applied at higher altitudes shall be derated in accordance with the manufacturer's instructions).

b. Non-operating altitude: Sea level to 12,000 m 40,000 ft.

c. Operating ambient temperature range: 0 to [40] [50] degrees C 32 to [104] [122] degrees F.

d. Non-operating and storage ambient temperature range: Minus 20 to plus 60 degrees C Minus 4 to plus 140 degrees F.

e. Operating relative humidity: 0 to 95 percent, without condensation.

1.6.2 Sound Pressure Levels

****
NOTE: UPS modules rated up to 125 kVA should have a dB rating of 65 dB or lower. UPS modules rated above 125 kVA should have a dB rating of 75 dB or lower.
****

Sound pressure levels produced by the UPS, when operating under full rated load, at a distance of [1.5 m 5 feet] [_____] in any direction from the perimeter of the unit, shall not exceed [75] [_____] dB as measured on the A scale of a standard sound level meter at slow response.

1.6.3 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.7 NAME PLATES

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

1.8 SPECIAL TOOLS

One set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment shall be provided.

1.9 OPERATION AND MAINTENANCE MANUALS

[Six] [_____] complete copies of operation manuals for the UPS System outlining the step-by-step procedures required for system startup, operation and shutdown shall be provided. The instructions shall include the manufacturer's name, equipment model number, service manual, parts list, and brief description of equipment and its basic operational features. [Six] [_____] complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides shall be provided. Corrective maintenance procedures shall identify the most probable failures and the appropriate repairs. Test measurement levels shall be referenced to specific test points on the installed equipment. Operation and maintenance manuals may be either combined or separate.

1.10 SPARE PARTS

The Contractor shall submit spare parts data for each different item of material and equipment specified, not later than the date of beneficial occupancy. The data shall include a complete list of parts and supplies with current unit prices and source of supply and an itemized price

breakdown of spare parts recommended for stocking. The recommended spare parts selected shall be those which, in the manufacturer's judgment, will be involved in the majority of maintenance difficulties encountered.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 LOAD PROFILE

****

NOTE: Determine power factor requirements. Edit Table as required.

The UPS capacity is specified in kW. kVA varies with power factor. A typical 60 kW UPS delivers 60 kW and 75 kVA at 0.8 power factor (lagging); 60 kW and 66.7 kVA at 0.9 power factor; and 60 kW and 60 kVA at 1.0 power factor.

The UPS may exhibit load interface problems with certain types of ac load. The items which present the greatest problems are motors, transformers, electric discharge lighting, and SCR and mag-amp power supplies. Problems with these loads are caused by either load nonlinearity or inrush currents required for their operation. The Contractor will be better able to accommodate specific applications if well-defined load data is available. Factors to consider include:

a. Type of load - Data processing equipment, main frame chilled water pump, etc.

b. Size of load - kVA or kW rating, horsepower, voltage and amperage of load.

c. Switching pattern - Unswitched; cycled daily; cycled hourly; operated by thermostat; building management system control.

d. Transient characteristics - Specify inrush current magnitude and duration (i.e., 15 times steady state rms current for 1/4 cycle for electric discharge lighting); range of power factor variation (i.e., as low as 0.4 lagging for electric discharge lighting); voltage dip.

e. Steady-state characteristics - specify range of power factor, particularly if outside the 0.8 lagging to 1.0 range. UPS derating is normally required for the unusual circumstance of loads at

leading power factor. Consult vendors if in doubt. In some cases a demand factor might be applicable to the load.

f. Special factors - Harmonic characteristics; factors that vary with temperature or age. The designer may vary the load profile format. Estimated or approximated load data may be used in the absence of exact information but should be so identified.

The designer should carefully evaluate the UPS application to anticipate problems and to adjust the design accordingly. The problems associated with UPS/load interaction can be reduced by:

LARGE TRANSFORMER APPLICATION

a. Using a transformer specifically designed for the transient specifications of the UPS.

b. Using a UPS with operating characteristics that will not cause the transformer to saturate.

MOTOR APPLICATION

a. Using a UPS capable of providing motor inrush without current limiting.

b. Transferring the load bus to an alternate source to start the motor and retransferring to the UPS after the motor has started.

c. Oversizing the UPS so the motor load represents a small portion of the UPS capacity.

d. Using a UPS with a modified inverter filter that is compatible with synchronous motors.

OTHER NONLINEAR LOADS

a. Using a UPS with a modified inverter filter.

b. Oversizing the UPS.

c. Avoiding connection of electric discharge lighting to the UPS. Other emergency sources should be used for this lighting.

****

The UPS system shall be compatible with the load characteristics defined in the LOAD PROFILE TABLE below and load configuration shown. Compensation for UPS/load interaction problems resulting from nonlinear loads or transformer and motor inrush shall be provided.

LOAD PROFILE TABLE

Type of load: [_____].

Size of load: [_____].

Switching pattern: [_____].

Transient characteristics: [_____].

Steady-state characteristics: [_____].

Special factors: [_____].

2.3 UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load at [0.8] [0.9] power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.3.1 System Capacity

****
NOTE: System capacity for single module UPS is same as module capacity. For multi-module UPS, select required redundancy. Parallel redundant UPS are usually N+1 redundant, where N is the number of modules needed to carry the full load.
****

Overall [_____] kVA, [_____] kW, [non] [N+1] [N+2] redundant, at [40] [50] degrees C.

2.3.2 Module Capacity

[_____] kVA, [_____] kW.

2.3.3 Battery Capacity

****
NOTE: Typical battery discharge times are 5, 10, 12, 15, and 30 minutes. If no emergency source is available, longer battery discharge time may be required.
****

Discharge time to end voltage: [15] [_____] minutes, at 25 degrees C 77 degrees F. Battery shall be capable of delivering 125 percent of full rated UPS load at initial start-up.

2.3.4 Static Switch

****
NOTE: The interrupting capacity requirements must be determined for each project distribution system.
****

[_____] amperes, [_____] amperes symmetrical interrupting capacity.

2.3.5 System Bus Bracing

Braced for [_____] amperes symmetrical interrupting capacity.

2.3.6 ac Input

****
NOTE: Total harmonic current distortion (THD) is usually specified as follows: modules 15-224 kVA 10 percent; modules above 225 kVA 5 percent. If UPS will be supplied from a generator, the generator capacity must be at least twice the UPS capacity if THD exceeds 5 percent.
****

a. Voltage [208] [380] [400] [480] [_____] volts line-to-line.

b. Number of phases: 3-phase, 3-wire, plus ground.

c. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.

d. Frequency: [50] [60] Hz, plus or minus 5 percent.

e. Power walk-in: 20 percent to 100 percent over 15 to 24 seconds.

f. Total harmonic current distortion (THD) reflected into the primary line: [5] [10] percent maximum.

g. Transformer sub-cycle inrush: 4 to 8 times full load rating.

2.3.7 ac Output

****
NOTE: If the output voltage is 120/208 V and the same voltage is not available for the static bypass and maintenance bypass, a transformer will be required in the bypass distribution system. Delete load sharing and redundant module for single module systems.
****

a. Voltage [208] [380] [400] [480] [_____] volts line-to-line, [120] [220] [277] [_____] volts line-to-neutral.

b. Number of phases: 3-phase, 4-wire, plus ground.

c. Voltage regulation:

(1) Balanced load: Plus or minus 1.0 percent.

(2) 50 percent load imbalance, phase-to-phase: Plus or minus 2 percent.

(3) No-load voltage modulation: Plus or minus 1 percent.

(4) Voltage drift: Plus or minus 1 percent over any 30 day interval (or length of test) at stated ambient conditions.

d. Voltage adjustment: Plus or minus 5 percent manually.

e. Frequency: [50] [60] Hz.

f. Frequency regulation: Plus or minus 0.1 percent.

g. Frequency drift: Plus or minus 0.1 percent over any 24 hour interval (or length of test) at stated ambient conditions when on internal oscillator.

h. Harmonic content (RMS voltage): 3 percent single harmonic, maximum; 5 percent total maximum with linear load. Voltage THD shall be less than 7 percent with up to 50 percent nonlinear load and a crest factor of less than 3 to 1.

i. Load power factor operating range: 1.0 to 0.8 lagging.

j. Phase displacement:

(1) Balanced load: Plus or minus 1 degree of bypass input.

(2) 50 percent load imbalance phase-to-phase: Plus or minus 3 degrees of bypass input.

k. Wave-form deviation factor: 5 percent at no load.

l. Overload capability (at full voltage) (excluding battery):

(1) 125 percent load for 10 minutes.

(2) 150 percent load for 30 seconds.

(3) 300 percent load for one cycle after which it shall be current limited to 150 percent until fault is cleared or UPS goes to bypass.

m. Load sharing of parallel modules: Plus or minus 5 percent of average load per module.

2.3.8 Transient Response

2.3.8.1 Voltage Transients

a. 50 percent load step/0 percent to 50 percent load: Plus or minus 8 percent.

b. 50 percent load step/50 percent to 100 percent load: Plus or minus 8 percent.

c. Loss or return of ac input: Plus or minus 1 percent.

d. Loss or return of redundant module:

(1) Manually: Plus or minus 8 percent.

(2) Automatically: Plus or minus 8 percent.

e. Automatic transfer of load from UPS to bypass: Plus or minus 4 percent.

f. Manual retransfer of load from bypass to UPS: Plus or minus 4 percent.

g. Response time: Recovery to 99 percent steady-state condition within 50 milliseconds after any of the above transients.

2.3.8.2 Frequency

a. Transients: Plus or minus 0.5 Hz maximum.

b. Slew Rate: 1.0 Hz maximum per second.

2.3.9 Efficiency

****

NOTE: Minimum efficiencies at full load are as follows:

UPS capacity	Single Module	Multi-Module
15 kVA to 30 kVA	80 Percent	---
31 kVA to 125 kVA	85 Percent	---
Above 125 kVA	90 Percent	89 Percent

Delete system efficiency requirements for single module UPS systems.

****

a. Minimum Single-Module Efficiency: [90] [_____] percent at full load kW.

b. Minimum System Efficiency: 89 percent at full system load kW.

2.4 UPS MODULE

2.4.1 General Description

UPS module shall consist of a rectifier/charger unit and a 3-phase inverter unit with their associated transformers, synchronizing equipment, protective devices and accessories as required for operation.

2.4.2 Rectifier/Charger Unit

Rectifier/charger unit shall be solid state and shall provide direct current to the dc bus.

2.4.2.1 Input Protective Device

Rectifier/charger unit shall be provided with an input protective device. The protective device shall be sized to accept simultaneously the full-rated load and the battery recharge current. The protective device shall be capable of shunt tripping and shall have [_____] amperes symmetrical interrupting capacity. The protective device shall have provision for locking in the "off" position. A surge suppression device shall be installed at the UPS input to protect against lightning and switching surges.

2.4.2.2 Power Transformer

A dry-type, isolated-winding power transformer shall be used for the rectifier unit. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation material

when operating at full load. The transformer insulation shall be Class H, 150 degrees C rise. Transformer connections shall be accessible from the front.

2.4.2.3 Power Walk-In

Rectifier/charger unit shall be protected by a power walk-in feature such that when ac power is returned to the ac input bus, the total initial power requirement will not exceed 20 percent of the rated full load current. This demand shall increase gradually to 100 percent of the rated full load current plus the battery charging current over the specified time interval.

2.4.2.4 Sizing

Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored, with the input protective device closed.

2.4.2.5 Battery Charging Current

****

NOTE: Delete second step current limiting if the UPS system will not be supplied with ac power from an auxiliary generator system or if the generator has been sized to accommodate the recharge current of the battery.

****

a. Primary current limiting: Battery-charging current shall be voltage regulated and current limited. The battery-charging current limit shall be separately adjustable from 2 percent to 25 percent of the maximum discharge current. After the battery is recharged, the rectifier/charger unit shall maintain the battery at full float charge until the next operation under input power failure. Battery charger shall be capable of providing equalizing charge to the battery.

b. Second step current limiting: The rectifier/charger unit shall also have a second-step battery current limit. This second-step current limit shall sense actual battery current and reduce the input power demand for battery recharging to 50 percent (adjustable from 30 percent to 70 percent) of the normal rate without affecting the system's ability to supply full-rated power to the connected load. The second-step current-limit circuit shall be activated by a dry contact signal from the generator set controls and shall prevent normal rate battery recharging until utility power is restored.

2.4.2.6 Output Filter

Rectifier/charger unit shall have an output filter to minimize ripple current supplied to the battery; the ripple current into the battery shall not exceed 3 percent RMS.

2.4.2.7 dc Voltage Adjustment

Rectifier/charger unit shall have manual means for adjusting dc voltage for battery equalization, to provide voltage within plus 10 percent of nominal float voltage.

2.4.2.8 Battery Isolation Protective Device

Module shall have a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating shall be as required by system capacity and shall incorporate a shunt trip as required by circuit design. The protective device shall have provision for locking in the "off" position.

2.4.3 Inverter Unit

Inverter unit shall be a solid-state device capable of accepting power from the dc bus and providing ac power within specified limits.

2.4.3.1 Output Overload

The inverter shall be able to sustain an overload as specified across its output terminals. The inverter shall not shut off, but shall continue to operate within rated parameters, with inverse-time overload shutdown protection.

2.4.3.2 Synchronism

The inverter shall normally operate in phase-lock and synchronism with the bypass source. Should the bypass source frequency deviate beyond 60 Hz by more than 0.5 Hz, the internal frequency oscillators contained in the power module shall be used to derive the new frequency reference. Upon restoration of the bypass source within the required tolerance, the inverter shall resynchronize with that source at a slew rate not exceeding the specified rate. The oscillator shall be temperature compensated and shall be manually adjustable. The design of the oscillator and synchronizing circuits shall be such that failure of any associated component, connector pin, terminal lead wire or dc power source in either the open or shorted mode shall affect only one inverter leg. Such failure shall not cause transient disturbance of the critical load in excess of the stated limits.

2.4.3.3 Phase Balance

Electronic controls shall be incorporated to provide individual phase voltage compensation to obtain phase balance.

2.4.3.4 Modular Construction

Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.

2.4.3.5 Output Protective Device

The output protective device shall be capable of shunt tripping and shall have interrupting capacity as specified. Protective device shall have provision for locking in the "off" position.

2.4.3.6 Output Transformer

The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to [K-13] [_____] nonlinear loads as described in IEEE C57.110.

2.4.3.7 Modular Inverter Isolation

****
NOTE: Delete for single module UPS system.
****

Each inverter in the UPS system shall have fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits.

2.4.4 External Protection

UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.4.5 Internal Protection

UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.4.6 Parallel Operation

****
NOTE: Delete for single module UPS system.
****

For parallel operation, the protection system shall have control logic capable of isolating only the faulted module, and shall not shut down the entire UPS system upon a fault in one module. Open protective devices shall be indicated by an alarm and indicator light.

2.5 STATIC BYPASS TRANSFER SWITCH

A static bypass transfer switch shall be provided as an integral part of the UPS and shall consist of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass ac power source, without exceeding the transient limits specified herein,

when a malfunction occurs in the UPS or when an external overload condition occurs. The power section of the static bypass transfer switch shall be provided as a plug-in type assembly to facilitate maintenance. The static bypass transfer switch shall be used to connect the bypass ac power source or the UPS inverter output to the critical load when required, and shall have the following features:

2.5.1 Uninterrupted Transfer

The static bypass transfer switch shall automatically cause the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. Inverter failure.

2.5.2 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output shall current-limit for 200 milliseconds minimum. The inverter shall then turn off and an interrupted transfer to the bypass ac power source shall be made. If the bypass ac power source is beyond the conditions stated below, an interrupted transfer shall be made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.5.3 Manual Transfer

It shall be possible to make a manually-initiated static transfer from the system status and control panel by turning the UPS inverter off.

2.5.4 Automatic Uninterrupted Forward Transfer

The static bypass transfer switch shall automatically forward transfer, without interruption after the UPS inverter is turned "on", or after an instantaneous overload-induced reverse transfer has occurred and the load current has returned to less than the unit's 100 percent rating.

2.5.5 Forced Transfer

The control logic circuitry shall provide the means of making a forced or reverse transfer of the static bypass transfer switch on an interrupted basis. Minimum interruption shall be 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.5.6 Overload Ratings

The static bypass transfer switch shall withstand the following overload conditions:

a. 2000 percent of UPS output rating for two cycles.

b. 200 percent of UPS output rating for 5 minutes.

c. 125 percent of UPS output rating for 10 minutes.

2.5.7 Static Switch Disconnect

****
NOTE: Delete if the static switch is of the draw-out type.
****

A static switch disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The switch shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.6 MAINTENANCE BYPASS SWITCH

2.6.1 General

****
NOTE: Delete for multi-module UPS systems. For multi-module UPS systems a UPS maintenance bypass should be incorporated into the UPS output switchgear.
****

A maintenance bypass switch shall be provided as an integral part of the UPS and located within the UPS module. The maintenance bypass switch shall provide the capability to continuously support the critical load from the bypass ac power source while the UPS is isolated for maintenance. The maintenance bypass switch shall be housed in an isolated compartment inside the UPS cabinet in such a way that service personnel will not be exposed to electrically live parts while maintaining the unit. Switch shall contain a maintenance bypass protective device and a module isolation protective device.

2.6.2 Load Transfer

The maintenance bypass switch shall provide the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.6.3 Load Bank Protective Device

****
NOTE: Delete if the ability to load bank test the UPS system is not required.
****

A load bank protective device shall be provided to allow the UPS system to

be tested using a portable load bank. The load bank protective device shall be connected on the line side of the maintenance bypass switch isolation protective device.

2.7 MODULE CONTROL PANEL

The UPS module shall be provided with a control/indicator panel. The panel shall be on the front of the UPS module. Controls, meters, alarms and indicators for operation of the UPS module shall be on this panel.

2.7.1 Module Meters

2.7.1.1 Monitored Functions

****
NOTE: Delete bypass voltage, output kilovars and output kWh for multi-module systems. These meters will be on the system control cabinet.
****

The following functions shall be monitored and displayed:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Battery voltage.

e. Battery current (charge/discharge).

f. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

g. Output current, all three phases.

h. Output frequency.

i. Output kilowatts.

j. Elapsed time meter to indicate hours of operation, 6 digits.

k. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

l. Output kilovars.

m. Output kilowatt hours, with 15-minute demand attachment.

2.7.1.2 Meter Construction

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits).

2.7.2 Module Controls

****
NOTE: Delete transfer switch references for

multi-module systems. These controls will be on the system control cabinet.

****

Module shall have the following controls:

a. Lamp test/reset pushbutton.

b. Alarm test/reset pushbutton.

c. Module input protective device trip pushbutton, with guard.

d. Module output protective device trip pushbutton, with guard.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard.

g. dc voltage adjustment potentiometer, with locking guard.

h. Control power off switch.

i. UPS/bypass transfer selector switch.

j. Static bypass transfer switch enable/disable selector switch.

2.7.3 Module Alarm Indicators

****

NOTE: Delete last 12 items for multi-module UPS systems. These alarms will be on the system control cabinet.

****

Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.

a. Input ac power source failure.

b. Input protective device open.

c. Output protective device open.

d. Overload.

e. Overload shutdown.

f. dc overvoltage.

g. dc ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower failure.

l. Input transformer overtemperature.

m. Inverter transformer overtemperature.

n. Equipment overtemperature.

o. Operating on internal oscillator.

p. Fuse blown.

q. Control power failure.

r. Charger off.

s. Inverter off.

t. Emergency off.

u. UPS on battery.

v. Critical load on static bypass.

w. Static bypass transfer switch disabled.

x. Inverter output overvoltage.

y. Inverter output undervoltage.

z. Inverter output overfrequency.

aa. Inverter output underfrequency.

bb. Bypass source overvoltage.

cc. Bypass source undervoltage.

dd. Bypass source overfrequency.

ee. Bypass source underfrequency.

ff. Bypass source to inverter out of synchronization.

2.7.4 Module Mimic Panel

****
NOTE: Delete the requirement for the four additional functions for multi-module UPS systems. These indicators will be on the system control cabinet.
****

UPS module shall have a mimic panel in the format of a module single-line diagram, with status indicators for input, output, battery protective devices, and battery disconnect switch. Each protective device shall have indicators for open (green) and closed (red), to give positive indication. The mimic panel shall provide indication of the following additional functions:

a. Charger on (functional).

b. UPS on-line (inverter furnishing load power).

c. UPS on-bypass (static switch operating).

d. System alarm (flashes for abnormalities, minor or major faults).

2.7.5 Module Emergency Off Button

Pressing the emergency off button shall cause the affected module to be disconnected from the system, via its input protective device, output protective device, and battery protective device. Activation of this button shall not affect the operation of the remainder of the system.

2.8 SYSTEM CONTROL CABINET

****
NOTE: Delete for single module UPS systems.
****

2.8.1 General Description

The multi-module UPS system shall be provided with a separate control cabinet for system output, summary monitoring, and control. This unit shall contain; bus bar connections to collect the output from each module, the static switch and its bypass breaker, the UPS system output protective device, and the UPS output switchgear.

2.8.2 UPS Output Switchgear

The UPS output switchgear shall consist of a main protective device feeding the UPS output switchgear critical load bus, a load bank protective device (connected on the line side of the main protective device), a maintenance bypass protective device and associated feeder protective devices for the critical loads.

2.8.2.1 Interlocking

****
NOTE: Delete references to load bank protective device if not used.
****

The main protective device and the load bank protective device shall be interlocked to prevent both being closed at the same time. The maintenance bypass protective device shall be interlocked with the UPS system output protective device and the static bypass switch. The maintenance bypass protective device shall not be capable of closing until the static bypass switch is closed and the UPS system output protective device is open. Once the maintenance bypass protective device is closed, the UPS output switchgear main protective device shall be capable of opening to isolate the critical loads from the UPS output. The load bank protective device as well as the UPS system output protective device shall then be capable of closing to permit load bank testing.

2.8.2.2 Switchgear

UPS output switchgear shall be provided in accordance with Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.8.3 System Control Panel

A separate control panel shall be provided for the overall UPS system. The panel shall be on the front surface of the system cabinet. The controls, meters, alarms and indicators for operation of the UPS system shall be on this panel.

2.8.3.1 System Meters

****
NOTE: Delete maintenance bypass metering functions if there is no maintenance bypass.
****

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits). ac voltages shall be measured as true RMS voltages.

The following functions shall be monitored:

a. Output voltage, phase-to-phase and phase-to-ground (all three phases).

b. Output current, all three phases.

c. Output frequency.

d. Bypass voltage, phase-to-phase and phase-to-ground (all three phases).

e. Output kilowatts.

f. Output kilovars.

g. Output kVA.

h. Output kilowatt-hours, with demand attachment.

i. Maintenance bypass voltage, phase-to-phase and phase-to-ground (all three phases).

2.8.3.2 System Controls

The system cabinet shall include the following controls:

a. Lamp test/reset.

b. Alarm test/reset.

c. Voltage adjustment potentiometer.

d. Emergency off pushbutton with protective cover.

e. UPS/bypass transfer selector switch.

f. Static switch enable/disable selector switch.

g. Control power off switch.

2.8.3.3 System Alarm Indicators

The system control panel shall contain indicators for the following additional alarm items. Any one of these alarm conditions shall also activate the audible alarm. Each new alarm shall register without affecting previous alarms.

a. Module summary alarm, one for each UPS module.

b. UPS on battery.

c. Low battery voltage.

d. Critical load on bypass.

e. Static switch disable.

f. Output overvoltage.

g. Output undervoltage.

h. Output overfrequency.

i. Output underfrequency.

j. Overload.

k. Bypass source overvoltage.

l. Bypass source undervoltage.

m. Bypass source overfrequency.

n. Bypass source underfrequency.

o. Bypass source to inverter out of synchronization.

p. Equipment overtemperature.

q. Control power failure.

2.8.3.4 System Mimic Panel

The system control panel shall contain a mimic panel in the format of a single-line diagram, with status indicators for the following items:

a. Module on-line, one per UPS module.

b. UPS output protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

c. Static bypass protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

d. Static switch status, one for connected (red), and one for

disconnected (green).

2.8.3.5 Emergency Off

Pressing the emergency off button shall cause the module input, output, and battery circuit breakers to open, completely isolating the UPS system from sources of power. The critical load shall be transferred to the bypass source when this occurs.

2.9 SELF-DIAGNOSTIC CIRCUITS

****
NOTE: Delete if self-diagnostic circuits are not required.
****

The control logic shall include status indicators for trouble-shooting the control circuits. These indicators shall be mounted on the circuit card edge or face such that they will be visible without repositioning the card, and shall be labeled with the function name.

2.10 REMOTE MONITORING PANEL

****
NOTE: Delete if a remote monitoring panel is not required.
****

A remote monitoring panel shall be provided to monitor system status. The panel shall be designed for wall mounting near the critical load.

2.10.1 Indicators

Minimum display shall include the following indicators:

a. Load on UPS.

b. Load on battery.

c. Load on bypass.

d. Low battery.

e. Summary alarm.

f. New alarm (to alert the operator that a second summary alarm condition has occurred).

2.10.2 Audible Alarm

****
NOTE: Delete system cabinet reference for single-module UPS systems.
****

Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the module or on the system cabinet.

2.11 COMMUNICATIONS AND DATA ACQUISITION PORT

****
NOTE: Delete if a communications port is not required. Delete control capability if not required.
****

An [RS 232C] [RS 485] communications and data acquisition port shall be provided. This port shall allow the system parameters, status, alarm indication and control panel functions specified to be remotely monitored and controlled.

2.12 TEMPERATURE CONTROL

2.12.1 General

Cabinet and enclosure ventilation shall be adequate to ensure that components are operated within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. The cooling fans shall continue operation if UPS input power is lost. Redundancy shall be provided so that failure of one fan or associated circuit breaker will not cause an overheat condition. Cooling air shall enter the lower front of the cabinets and exhaust at the top. Blower power failure shall be indicated as a visual and audible alarm on the control panel. Air inlets shall have filters that can be replaced without opening the cabinet doors.

2.12.2 Blower Power Source

Blower power source shall be internally derived from the input and output sides of UPS module, with automatic transfer arrangement.

2.12.3 Temperature Sensors

Temperature sensors shall be provided to monitor the air temperature. Separate sensors shall monitor the temperature of rectifier and inverter heat sinks. Separate sensors shall also monitor the transformer temperature. Critical equipment overtemperature indication shall start a timer that shall shut down the UPS system if the temperature does not return below the setpoint level in [_____] minutes.

2.13 BATTERY SYSTEM

****
NOTE: Valve-regulated (sealed) batteries are typically used for UPS systems up to 200 kVA. Wet-cell batteries are typically used for UPS systems of 80 kVA and above. Make choices as required. Delete module references if not required.

a. Table 1, developed from information in IEEE 446, lists the characteristics of each battery type. Lead-calcium batteries require considerable time to return to full equal charge on all cells following discharge. For this reason, other battery types may be required where frequent and prolonged outages occur.

TABLE 1

Battery Type	Characteristics
Lead-Antimony*	14-25 year life on float charge. Capacity decreases with decrease in temperature. Requires periodic (at least twice/year) equalizing charge.
Lead-Calcium	20-30 year life on float charge. Capacity decreases with decrease in temperature. Does not require periodic equalizing charge if floated between 2.20 and 2.25 volts per cell.
Nickel-Cadmium**	Life in excess of 25 years on float charge. Better low temperature capacity than other types. Very little gassing under charge. Not damaged by complete discharge. Requires periodic equalizing charge. High in cost.

*** Lead-antimony batteries use more water as they age due to high charging current, and therefore require more maintenance with aging. For this reason they are not available for valve-regulated (sealed) applications.**

**** Nickel-cadmium batteries, if not charged and discharged periodically, may develop a "memory" and fail to deliver their design capacity when required. Also, cadmium is on the EPA's list of toxic substances. There may be difficulty in disposing of expended batteries.**

b. Battery Discharges and Service Life

Battery warranties are based on a given number of discharges per year (at various rates) during the life of the battery. The warranty may be voided if the number of discharges per year exceeds the manufacturer's specifications.

Battery service life is considered to end when the battery fails to deliver 80 percent of its rated capacity. Since UPS systems are always expected to deliver 100 percent capacity, the battery must be sized to deliver 100 percent of the UPS rating at the end of its service life, which means the battery must be oversized initially. Capacity determination should be made in accordance with the "performance test" guidelines of IEEE Std 450. If the UPS has

been oversized for specialized loads as described in notes of paragraph LOAD PROFILE, the battery system may be sized for the actual load.

c. Specific Gravity and Charging Volts Per Cell:

Float Volts per Cell

Nominal Specific Gravity	Lead Antimony	Lead Calcium
1.170	2.13 to 2.20	----
1.215 (std.)	2.15 to 2.22	2.17 to 2.26
1.250	----	2.21 to 2.30
1.300	----	2.25 to 2.34

Equalizing Volts per Cell

Nominal Specific Gravity	Lead Antimony	Lead Calcium
1.170	2.33	----
1.215 (std.)	2.33	2.33 to 2.38
1.250	----	2.38 to 2.43
1.300	----	2.45 to 2.50

Increasing the specific gravity for a given cell size will increase its output, but may reduce its life. In some applications where battery physical size must be kept as small as possible, the higher specific gravities are specified.

d. End Voltage (per cell).

The end voltage (per cell) is the voltage at which the battery is set to disconnect from the UPS to prevent overdischarging the battery. End voltages used in the industry are 1.60, 1.63, 1.65, 1.67 (standard), 1.70, and 1.75 volts per cell. Any discharge below 1.50 volts per cell can damage the battery. Raising the end voltage will increase the battery size for a given load if other parameters are not changed.

e. Ventilation.

Ventilation of storage battery areas is required by NFPA 70. A safe environment for such areas exists where the concentration of gaseous hydrogen does not exceed 2 percent accumulation per unit volume. Factors used to determine this condition are the size and type of battery to be charged; room volume; maximum volume of hydrogen gas emitted during charging; and ventilation rate. Approximately 0.016 cubic foot per hour of hydrogen gas is produced from each fully charged wet cell per charging ampere. Valve-regulated cells typically produce considerably

less. Once sufficient ventilation is produced, no need exists for explosion-proof wiring, vapor-proof fixtures, or other special provisions. Mechanical ventilation (an exhaust fan) should be provided in accordance with the battery manufacturer's recommendations.

f. Battery Room Temperature.

Battery system performance may be affected by battery room temperatures above or below the standard 25 degrees C (77 deg. F) at which batteries are rated. Battery capacity is reduced at lower temperatures and battery life expectancy is reduced at sustained temperatures greater than 30 degrees C (86 deg. F). Batteries should be derated if battery room temperatures are expected to vary more than plus or minus 2.78 degrees from the standard 25 degrees C.

g. Safety Considerations.

Large battery rooms will normally require eyewash facilities and should be coordinated with the plumbing designer. Storage batteries and charging equipment should not be installed in hazardous locations. Safety equipment for the battery room should include the following: full coverage face shield, rubber or neoprene long cuff gloves, rubber or neoprene apron, battery maintenance blanket, insulated maintenance tools, acid absorption and neutralization supplies and typical electrical safety board equipment.

****

2.13.1 General

A storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module. The battery shall be of heavy-duty, industrial design suitable for UPS service. The cells shall be provided with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Intercell connectors shall be sized to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Cell and connector hardware shall be stainless steel of a type capable of resisting corrosion from the electrolyte used.

2.13.2 Battery Ratings

a. Type: [lead calcium] [lead antimony] [nickel cadmium].

b. Specific gravity when fully charged: [1.215] [_____].

c. End voltage [1.67] [_____] volts per cell.

d. Float voltage: [2.17 to 2.26] [2.15 to 2.22] volts per cell.

e. Equalizing voltage: [2.33 to 2.38] [_____] volts per cell.

2.13.3 Battery Construction

The battery shall be of the [valve-regulated, sealed, non-gassing, recombinant type] [wet-cell type and shall be supplied complete with thermometer and hydrometer holder].

2.13.4 Battery Cabinet

****
NOTE: Delete if a battery cabinet is not required.
****

The battery pack assembly shall be furnished in a battery cabinet matching the UPS cabinet. The battery cabinet shall be designed to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. External wiring interface shall be through the bottom or top of the assembly. A smoke and high temperature alarm shall annunciate detection of either smoke or high temperature within the battery cabinet.

2.13.5 Battery Rack

****
NOTE: Delete if a battery rack is not required. Three tier racks should be used only where floor space is limited. They increase floor loading and make maintenance more difficult.
****

The battery shall be provided with a suitable number of [two-tier] [three-tier] racks to fit the room layout shown. Battery rack shall be steel and shall be protected with electrolyte-resistant paint. Battery rack shall be shipped unassembled and shall include hardware necessary for assembly. Each rack shall be complete with bus bars to accommodate cables from UPS module. Bus bar connectors for battery-to-battery connections and high-flex multi-stranded copper cable (ASTM B 173 stranding class H) with proper cable supports for connecting top row of batteries to bottom row of batteries at rack ends shall be provided. End sections shall be cut to length to prevent wasting floor space.

2.13.6 Cell-Terminal Covers

Acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed shall be provided.

2.13.7 Battery Disconnect

Each battery pack assembly shall have a fused disconnect switch provided in a NEMA 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Switch shall be complete with line side and load side bus bars for connection to battery cells. Switch shall be rated [_____] V dc, [_____] amperes, 3-pole with interrupting rating as required by system capacity, and shall have an external operator that is lockable in the "off" position.

2.13.8 Seismic Requirements

****

NOTE: Provide seismic requirements for battery supports, if a Government designer is the Engineer of Record, and show on the drawings. Delete the inappropriate bracketed phase. Sections 13 48 00, 13 48 00.00 10, and 26 02 48.00 10, properly edited, must be included in the contract documents.

****

The battery support system shall [conform to Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, AND 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT] [be as indicated].

2.13.9 Battery Monitor

A battery monitor shall be provided for each battery pack assembly. At a minimum, this device shall monitor the following parameters:

a. Total system voltage.

b. Ambient room temperature.

c. Total battery discharge cycles with a duration of [30 seconds or less] [greater than 30 seconds but less than 5 minutes] [greater than 5 minutes].

The monitor shall also record the total accumulated discharge minutes and accumulated battery system discharge kW hours.

2.14 FACTORY TESTING

****

NOTE: Edit as required for single module system.

The designer should carefully evaluate the UPS application and the user's mission to determine critical tests for the UPS that will ensure UPS/load compatibility. These tests should be conducted at the factory and the results validated prior to shipment to the site. The required UPS/load interaction can be achieved by requesting the following tests plus any other tests the designer deems necessary:

a. Tests to ensure that the UPS rated power factor is verified;

b. Tests to ensure that the UPS system will operate in total accord and support the rated load;

c. Tests to ensure that the UPS system can deal with load anomalies (odd harmonics, etc.) associated with the user's equipment load.

****

The UPS system shall be factory tested to meet the requirements specified using a test battery (not the battery to be supplied with the system). UPS module shall be factory load tested as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter

readings taken every 30 minutes. Load shall be balanced at rated kVA and rated power factor. Factory tests for the UPS module shall be run under full load, and will be witnessed by the Government. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. As a minimum, the factory tests shall include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. The tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings. The Government shall be notified in writing at least 2 weeks before testing. Factory-test time shall not be used for system debugging and/or checkout. Such work shall be done prior to notifying the Government that the system is ready for testing. Factory tests shall be performed during normal business hours. The system shall be interconnected and tested for an additional 8 hours to ensure proper wiring and performance.

2.14.1 Transient Tests

Transient tests shall be conducted using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests shall include 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. A recording instrument equipped with an event marker shall be used.

2.14.2 Efficiency Tests

Testing for efficiency shall be performed at zero output up to 100 percent of stated kVA output in 25 percent steps, [0.8] [0.9] power factor, with battery fully charged and floating on the dc bus, with nominal input voltage, and with modules connected to the system to represent actual operating conditions.

2.15 INSPECTION

Inspection before shipment is required. The manufacturer shall notify the Government at least 2 weeks before shipping date so that an inspection can be made.

PART 3 EXECUTION

3.1 INSTALLATION

The UPS system shall be set in place, wired and connected in accordance with the approved shop drawings and manufacturer's instructions. The UPS battery shall be shipped to the site dry.

3.2 FIELD SUPERVISION, STARTUP AND TESTING

The services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installation, adjustment and testing of the equipment. The representative shall check the wiring between equipment, start up the system, and field test the functions, interlocks and protective devices to ensure that the total system is functioning according to the intent of the design. The field tests shall be performed under the supervision of a factory-trained representative of the equipment manufacturer and witnessed by the Government. The Government shall be given 2 weeks written advance notice of the date and time when testing will be conducted.

3.2.1 Field Tests

As a minimum, the startup and field test procedures shall include the following:

a. Ensure that shipping members have been removed.

b. Check for damage (dents, scratches, frame misalignment, damage to panel devices, etc).

c. Ensure that interiors are free of foreign materials, tools and dirt.

d. Attach a phase rotation meter to the UPS input, output and bypass buses, and observe proper phase sequences.

e. Torque test bus connections at shipping splits. Also torque test battery connections.

f. Check each electrical bus for proper phasing and identification.

g. Check and test selector switches and meters for proper operation.

h. Check doors for proper alignment and operation.

i. Check and test each protective device for proper mechanical and electrical operation.

j. Check protective device overcurrent trip settings.

k. Check and test indicating lights for proper operation and color.

l. Perform onsite field test procedures.

m. Demonstrate to the Government that the specified functions and interlocks have been implemented.

n. Provide IEEE Std 450 battery installation certification.

o. Check key interlock key numbers, if used, to ensure agreement with interlocking scheme.

3.2.2 Load Test

****
NOTE: Edit as required, depending upon whether a temporary or permanent load bank is to be provided and on the type of UPS system. This paragraph may be deleted for small UPS systems.
****

The installed system shall be load tested for a continuous 24 hour period by means of resistive load banks. The system shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. [Load banks will be available onsite and shall be connected to UPS equipment by the Contractor.] [The equipment manufacturer shall provide resistive load banks of total kW load of equipment to facilitate startup under load conditions, and to conduct load tests described above.]

Instrument readings shall be recorded every half hour for the following:

a. Input voltage (all three phases, for each module).

b. Input current (all three phases, for each module).

c. Input frequency.

d. Battery voltage for each module.

e. Output voltage (all three phases, for each module).

f. Output current (all three phases, for each module).

g. Output kilowatts for each module.

h. Output frequency.

i. Output voltage (all three phases - system output).

j. Output current (all three phases - system output).

k. Output kilowatts (system output).

3.2.3 Full Load Burn In Test

****
NOTE: Delete emergency source testing requirements if no emergency source is available.
****

The installed system shall undergo an additional full load burn-in period of 24 continuous hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. During the burn-in period, the following tests shall be performed:

a. With the UPS carrying maximum continuous design load and supplied from the normal source, switch [100 percent load] [50 percent load] on and off a minimum of five times within [the burn-in period] [_____].

b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described in step a. Also, verify that the UPS module rectifier charger unit(s) go into the second-step current limit mode.

c. With the UPS carrying maximum continuous design load and operating on battery power, repeat the switching operations described in step a above.

d. Continue operation on battery power for 1 minute, then restore normal power.

The Contractor shall furnish a high-speed dual trace oscillograph to monitor ten or more cycles of the above tests at the ON and OFF transitions and two typical steady-state periods, one shortly after the load is energized (at 30 to 60 seconds) and one after operation has stabilized (at 8 to 10 minutes). Four copies of the traces shall be delivered to the

Contracting Officer.

3.2.4 Battery Discharge Test

****
NOTE: Delete module references if not needed.
****

With the battery fully charged, the system shall undergo a complete battery discharge test to full depletion and a recharge to nominal conditions. Instrument readings shall be recorded every minute during discharge for the following:

a. Battery voltage for each module.

b. Battery current for each module.

c. Output voltage (all three phases) for each module.

d. Output current (all three phases) for each module.

e. Output kilowatts for each module.

f. Output voltage (all three phases - system output).

g. Output current (all three phases - system output).

h. Output kilowatts (system output).

i. Output frequency.

3.3 POSTING FRAMED DATA AND INSTRUCTIONS

Framed data and instructions containing wiring and control diagrams under glass or in laminated plastic shall be posted where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the system.

3.4 FIELD TRAINING

****
NOTE: Delete video tape references if not required.

Insert correct ratings and data for all bracketed items in the following six data sheet pages. The numbers within brackets are only examples and correct values should be inserted.
****

A field training course shall be provided for designated operating and maintenance staff members. Training shall be provided for a total period of 12 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance test. Field training shall cover the items contained in the operating and maintenance manuals. The 12 hours shall be divided into two sessions of 6 hours each. Each session shall be conducted on a different day. [Field training shall be videotaped and the tape shall be left with the Contracting Officer.] [A factory training videotape shall be provided as part of the training

materials.]

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 1 OF 6

	ITEM	SPECIFIED	SUBMITTED
	SYSTEM OPERATION	[SINGLE MODULE] [PARALLEL REDUNDANT] [PARALLEL NON REDUNDANT]	
	NUMBER OF SYSTEMS	[_____]	
GENERAL	NUMBER OF MODULES IN EACH SYSTEM	PRESENT [_____] FUTURE [_____]	
GENERAL	SYSTEM CAPACITY:		
GENERAL	PRESENT	[_____] kW/[_____] kVA	
GENERAL	FUTURE	[_____] kW/[_____] kVA	
	BATTERY	ONE PER MODULE	
	MTBF (SYSTEM)		
	MTTR		
	MODULE RATING	[_____] kW/[_____] kVA	
MODULE	DC VOLTAGE WINDOW	[_____] Vdc	
MODULE	INPUT/OUTPUT PROTECTIVE DEVICE INTERRUPT. RATING	[_____] A SYM.	
	MANUFACTURER	_____	
	TYPE	[LEAD-CALCIUM] [LEAD-ANTIMONY] [NICKEL-CADMIUM]	
BATTERY	DISCHARGE TIME TO END VOLTAGE AT FULL LOAD	[_____] MINUTES	
BATTERY	END VOLTAGE	[_____] V/CELL	
BATTERY	SPECIFIC GRAVITY	[_____]	
	FLOAT VOLTAGE	[_____] V/CELL	
	NUMBER OF CELLS	[_____] CELLS	

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 2 OF 6

	ITEM	SPECIFIED	SUBMITTED
B A T T	HYDROGEN GENERATION	_____	
	RECHARGE TIME TO 95% CAPACITY	10 X DISCHARGE	
S Y S T E M	PROTECTIVE DEVICE	[AIR POWER, DRAW-OUT] [_____]	
	MANUFACTURER	_____	
	INTERRUPTING RATE	[_____] A SYM.	
	STATIC SWITCH	[_____] A	
A C I N P U T	VOLTS, LINE/LINE	[_____] V	
	PHASES	[3-PHASE, 3-WIRE] [_____]	
	VOLTAGE RANGE	+ 10%, - 15%	
	FREQUENCY	[50] [60] Hz	
	FREQUENCY RANGE	+/- 5%	
	POWER WALK-IN 20% TO 100% LOAD	15 - 24 SECONDS	
	TOTAL HARMONIC DISTORTION REFLECTED-PRIMARY	[5% MAX (CURRENT)] [_____]	
	ORDER OF HARMONIC	_____	PERCENTAGE OF TOTAL
	2nd		
	3rd		
	4th		
	5th		
	6th		
	7th		
	8th		
	9th		
(FILL IN AS REQUIRED)			
	TRANSFORMER SUB-CYCLE INRUSH	[_____] x FULL LOAD	
	POWER FACTOR	[0.8] [0.9]	

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 3 OF 6

	ITEM	SPECIFIED	SUBMITTED
	VOLTAGE, LINE-LINE	[_____] V	
	PHASES	3-PHASE, 4-WIRE	
	POWER FACTOR	0.8 LAGGING, 1.0	
	VOLTAGE REGULATION		
	BALANCED LOAD	+/- 1.0%	
	50% IMBALANCE BETWEEN PHASES	+/- 2.0%	
	NO-LOAD MODULATION	+/- 1.0%	
	DRIFT (30 DAYS)	+/- 1.0%	
	VOLTAGE ADJUST.	+/- 5.0% MANUALLY	
A C	FREQUENCY	60 Hz	
	REGULATION	+/- 0.1%	
O U T	DRIFT (24 HRS.)	+/- 0.1%	
P U T	HARMONIC CONTENT		
	TOTAL (50% NON-LINEAR LOAD	7.0% MAX.	
	TOTAL (LINEAR LOAD)	5.0% MAX.	
	SINGLE HARMONIC (LINEAR LOAD)	3.0% MAX.	
	PHASE DISPLACEMENT		
	BALANCED LOAD	+/- 1.0 DEG. OF BYPASS	
	50% IMBALANCE	+/- 3.0 DEG. OF BYPASS	
	WAVE FORM DEVIATION FACTOR (NO LOAD)	5.0%	
	OVERLOAD CAPACITY		
	125%	10 MINUTES	
	150%	30 SECONDS	
	300%	MOMENTARY	

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 4 OF 6

	ITEM	SPECIFIED	SUBMITTED
	LOAD SHARING AMONG MODULES	+/- 5.0% OF AVERAGE LOAD	
	VOLT. TRANSIENT RESPONSE		
	50% STEP LOAD 0% to 50%	+/- 8.0%	
	50% STEP LOAD 50% to 100%	+/- 8.0%	
	LOSS OR RETURN OF INPUT	+/- 1.0%	
	LOSS OR RETURN OF A REDUNDANT MODULE		
	AUTOMATICALLY	+/- 8.0%	
	MANUALLY	+/- 8.0%	
A C O U T P U T	AUTO TRANSFER, AT FULL LOAD, FROM UPS TO BYPASS	+/- 4.0%	
	MANUAL TRANSFER, AT FULL LOAD, FROM BYPASS TO UPS	+/- 4.0%	
	RECOVERY TIME TO 99% STEADY-STATE COND.	50 MILLISECONDS	
	FREQUENCY TRANSIENT RESPONSE	+/- 0.5 Hz	
	SLEW RATE	1.0 Hz/SECOND	

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 5 OF 6

	ITEM	SPECIFIED	SUBMITTED
AC OUTPUT	EFFICIENCY @ FULL LOAD MODULE	[_____]%	
	SYSTEM	[_____]%	
	SYSTEM NOISE GEN. LEVEL @ 1.8 M 6 FT. FROM EQUIPMENT	[_____] DBA	
	OPERATING AMBIENT TEMPERATURE	0 to [40] [50] DEG. C 32 to [104] [122] DEG. F	
	STORAGE AMBIENT TEMPERATURE	-20 to +60 DEG. C -4 to +140 DEG. F.	
ENVIRONMENTAL	BATTERY ROOM AMBIENT TEMP.	25 DEG. C 77 DEG. F NOMINAL	
	RELATIVE HUMIDITY (NON-CONDENSING)	0 - 95%	
	BAROMETRIC PRESSURE (ALTITUDE)		
	OPERATING		
	OPERATING	0 - [_____] FT.	
	NON-OPERATING	12,200 M	
	NON-OPERATING	0 - 40,000 FT.	
	HEAT REJECTION	_____	
	MODULE		
	SYSTEM		
PHYSICAL DATA	MODULE	_____	
	SIZE		
	WEIGHT		
	SYSTEM CABINET	_____	
	SIZE		
	WEIGHT		

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 6 OF 6

	ITEM		SPECIFIED	SUBMITTED
PHYSICAL DATA	BATTERY		_____	
	SEISMIC PARAMETERS			
	RACKS	SIZE		
		WEIGHT		
	CELLS	SIZE		
		WEIGHT		
	DISCON-NECT	SIZE		
		WEIGHT		

-- End of Section --