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NOT MEASUREMENT SENSITIVE

DOE-SPEC-3019-96
August 1996

# DOE SPECIFICATION

# VALVE-REGULATED TYPE LEAD-ACID STORAGE BATTERIES


**U.S. Department of Energy**
**Washington, D.C. 20585**

**FSC 6140**

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## FOREWORD

1. Use of this purchase specification is not mandatory. User should review the document and determine if it meets the user's purpose.

2. Comments (recommendations, additions, and deletions) and any pertinent data that may be of use in improving this document should be addressed to: Manager, DOE Technical Standards Program (EH-62), U.S. Department of Energy, Washington, DC 20585, or by using the self-addressed Standardization Document Improvement Proposal (DOE Form 1300.3) appearing at the end of this document.

3. This document contains a "fill-in-the-blanks" guide specification for the procurement of sealed valve-regulated type lead-acid storage batteries, organized as follows:

- Parts 1 through 7: Technical requirements
- Appendix A: Technical requirements to be included in the proposal
- Appendix B: Battery system data sheets to be completed by each bidder (Seller) and submitted with the proposal
- Appendix C: Definitions of Terms (may or may not be included with the specification)
- Attachment 1: Battery room sketches and duty-cycle diagrams prepared by the purchaser (Owner)
- Attachment 2: Sample title page

4. Because this guide specification contains blanks for the specifier to enter quantities, both metric and inch-pound units have been noted where appropriate, with the metric unit in parentheses. Select one system or the other (not both) when using the specification.

5. Most of the guide specification is "boilerplate;" i.e., it will always remain the same from job to job. The portions of the specification that are job specific are highlighted for the specifier's attention in one of the following ways:

| ***FLAG*** | ***MEANING*** |
|---|---|
| *ATTENTION:* | These are explanatory notes that precede areas in the text requiring editing. The nature of the choice and the type of action (or research) required is explained in the note. |
| [item] | These are action items within the text of the specification. If the bracketed item is by itself, it is an optional requirement that may or may not be specified according to circumstances. If there are a pair of bracketed items, or a series of them, they represent alternate choices that may be made in accordance with varying circumstances; one (or more) of them ***must*** be chosen by the specifier. |
| [____] | A blank in the text means that the specifier must supply a specific value, text, or dimension. Blanks in the text are generally preceded by *ATTENTION:* notes that explain the nature of the value or dimension that must be supplied. |

6. After the specifier has finished supplying all the requested information in the guide specification, a word processor can incorporate all the choices made and delete all the *ATTENTION:* notes. What remains will be the finished specification that may be used as a bid document.

7. Appendices A and B, and Attachment 1 are to be used by each bidder as a guide for preparing the technical proposal.

8. Appendix C is a list of definitions of terms used in this document, and it is the specifier's option as to whether it is included with the specification for the bidder's edification.

## CONTENTS

APPENDICES



ATTACHMENTS

# DOE-SPEC-3019-96

## 1. SCOPE

***ATTENTION:***
***Select the appropriate use for the batteries and provide the name and location of the facility.***
*********

1.1 Purpose. This specification defines requirements for sealed valve-regulated type, lead-acid storage batteries and accessory equipment for [general purpose] [uninterruptible power supply (UPS)] [_____] applications, for [_____], located in [_____].
*Owner's facility*
*City, State*

***ATTENTION:***
***Define the following terms as used at this facility, to avoid confusion.***
*********

1.2 Definitions

1.2.1 Owner [_____]

1.2.2 Seller [_____]

1.3 Work to be provided. Seller shall provide the following:

a. Design, manufacture, shop test, and deliver fully-charged batteries and accessory equipment.

b. Deliver all equipment packaged to provide protection during transportation and recommended storage requirements.

c. Provide all data specified in accordance with the submittal schedule (refer to Section 4.0).

d. Provide technical manuals, [and] startup procedures, [and startup assistance] for the Owner.

e. Provide all special tools required for installation, startup, operation, maintenance, and adjustment.

***ATTENTION:***
***Include the following reference if a UPS system is being provided, and is specified separately.***
*********

f. Reference [Specification _____] [_____] for corresponding UPS requirements.

1.4 Work provided by the Owner.

***ATTENTION:***
***If the Owner's facility does not have the capability to provide the following services, add these items to paragraph 1.3 and delete here.***
**********

a. Installation

b. Cable interconnections between batteries and charger

c. Inter-rack/inter-[tier] [step] cables

1.5 Warranty. Seller shall warrant that the batteries shall perform as specified for a period of [10] [___] years.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent stated herein. Unless otherwise indicated, use the issue in effect on the date of request for quotation. Bring any conflicts between this specification and the referenced documents to the attention of the Owner, in writing, for resolution before taking any related action. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2.1 Government publications.

***Code of Federal Regulations (CFR)***

| | |
|---|---|
| 29 CFR 1910 | Occupational Safety and Health Standards (Fed/OSHA) |
| 29 CFR 1910.7 | Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL) |

(Copies of the above government documents are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

2.2 Consensus Standards

***Institute of Electrical and Electronics Engineers, Inc. (IEEE)***

| | |
|---|---|
| IEEE 100 | Dictionary of Electrical and Electronics Terms |
| IEEE 450 | Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations |

| | |
|---|---|
| IEEE 484 | Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations |
| IEEE 485 | Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations |
| IEEE 1187 | Recommended Practice for Installation Design and Installation of Valve-Regulated, Lead-Acid Storage Batteries for Stationary Applications (DRAFT - October 1994) |
| IEEE 1188 | Recommended Practice for Maintenance, Testing, and Replacement of Valve Regulated Lead-Acid Batteries for Stationary Applications (DRAFT - 4/4/94) |
| IEEE 1189 | Guide for Selection of Valve Regulated Lead-Acid (VRLA) Batteries for Stationary Applications (DRAFT - January 1995) |

***ATTENTION:***
***Change reference as required for the applicable building code.***
**********

***International Conference of Building Officials (ICBO)***

| | |
|---|---|
| ICBO UBC | Uniform Building Code |

***Building Officials and Code Administrators International (BOCA)***

| | |
|---|---|
| BOCA | BOCA National Building Code |

***Southern Building Code Congress, International (SBCCI)***

| | |
|---|---|
| SBCCI | Standard Building Code |

***National Fire Protection Association (NFPA)***

| | |
|---|---|
| NFPA 70 | National Electrical Code<br>Art. 480 Storage Batteries |
| NFPA 111 | Stored Electrical Energy and Standby Power Systems |

***Underwriters Laboratories, Inc. (UL)***

| | |
|---|---|
| UL 486A | Wire Connectors and Soldering Lugs for use with Copper Conductors |

(Copies of non-government publications are normally available from the organizations that prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.)

BOCA: Building Officials and Code Administrators, International
4051 W. Flossmoor Road
Country Club Hills, IL 60478-5795

IEEE: Institute of Electrical and Electronics Engineers
445 Hoes Lane, P.O. Box 1331
Piscataway, NJ 08855-1331

ICBO: International Conference of Building Officials
5360 Workman Mill Road
Whittier, CA 90601-2298

NFPA: National Fire Protection Association
One Batterymarch Park, P.O. Box 9101
Quincy, MA 02269-9101

SBCCI: Southern Building Code Congress, International
900 Montclair Road
Birmingham, AL 35213

UL: Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

2.3 Order of precedence. In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specified exemption has been obtained.

3. REQUIREMENTS

***ATTENTION:***
***Determine if cell jars only, or cell jars and covers shall be fire-retardant.***
**********

3.1 System characteristics. The storage batteries will be used to supply DC power [under emergency conditions] [_____] at the DC voltages and for the DC power system listed below. The batteries shall be in accordance with article 480 of NFPA 70. The batteries shall be complete in all respects, with all required accessories. Only sealed valve-regulated type lead-acid cells are acceptable. The cells provided shall have fire-retardant [jars] [jars and covers] and shall be provided with flame-arrester type vents.

***ATTENTION:***
***In items a through h below, enter the basic battery description of each battery string being purchased, as well as how each is to be identified and named. If there is more than one battery string, please indicate battery strings will be connected in a parallel configuration. Also enter the nominal system bus voltage and whether or not the battery will be used in a grounded system. DC systems usually operate ungrounded, except for telecommunication systems which generally have one side grounded. The number of cells per battery, multiplied by 2 volts per cell, should equal the nominal system voltage.***
*********************

| | | |
|---|---|---|
| a. | Designation of Battery String | No. [1] [___] [Parallel Configuration] |
| b. | Nominal DC System (Battery) Voltage | [___] V DC |
| c. | Battery is Used in a Grounded DC System | [Yes] [No] |
| d. | Number of Cells per Battery Jar | [___] minimum [___] maximum |
| e. | Grid Alloy | [Pure Lead] [Lead-Calcium] [Lead-Antimony] [Lead-Selenium] |
| f. | Cell Type | [Absorbed Glass Mat] [Gel Cell] |
| g. | End-of-Duty Cycle Voltage or Minimum Voltage During Duty Cycle | [1.75] [___] V/cell |

3.2 Performance.

***ATTENTION:***
***Insert the required information in the following paragraph.***
*********************

3.2.1 Operating environment. Each battery and associated equipment shall meet the performance requirements of this specification while operating under the environmental conditions specified below.

| | | |
|---|---|---|
| a. | Battery String Designation | No. [1] [___] |
| b. | Elevation Above Mean Sea Level | [___ ft (___ m)] |
| c. | Battery Room Ambient Temperature Range | [70 to 80°F (21 to 27°C)] [___ to ___°F (___ to ___°C)] |
| d. | Battery Room Ambient Design Temperature | [77°F (25°C)] [___°F (___°C)] |
| e. | Battery Room Maximum Design Temperature (i.e., HVAC Failure) | [___]°F (___°C) |

| | | |
|---|---|---|
| f. | Battery Room Relative Humidity Range | [20 to 55%] [___ to ___%] |
| g. | Other (e.g. salt-laden air, dust) | [None] [_____] |
| h. | Battery Room Layout | [Sketch No.___] [Drawing No.___] (Attachment 1) |

***ATTENTION:***
***Select one of the following paragraphs 3.2.2. Use the first paragraph for UPS applications. Enter the kVA rating and efficiency of the UPS to which the purchased battery will deliver power, and the battery rated life.***
**********

3.2.2 Duty cycle. Each battery shall supply UPS load of [___] kVA at 0.8 power factor (PF) lagging ([___] kVA at 1.0 PF) for [15] [___] minutes. Inverter full-load efficiency shall be approximately [90%.] [___%.] Each battery shall be rated for a [10-year] [___-year] life to operate with the following current and voltage harmonics fed back from the UPS:

***ATTENTION:***
***Enter the maximum current and voltage harmonics to which the battery will be exposed. These values should be available from the UPS manufacturer; also consult IEEE 519 for guidance.***
**********

a. Maximum Current Harmonics (p-p): [5%] [___%]

b. Maximum Voltage Harmonics (p-p): [10%] [___]

***ATTENTION:***
***Use this paragraph for general-purpose applications. Verify the duty cycle (Appendix B) is correct, and attached to the specification. Enter the lowest electrolyte temperature expected.***
**********

3.2.2 Duty cycle. The batteries shall supply power for the duty cycle noted in Appendix B and diagrammed in Attachment 1, when the temperature in the battery room is at its lowest level. Note that this duty cycle represents the loads to be served by the battery and does not include design margin, aging or temperature correction factors (refer to paragraph 3.2.6). Electrolyte temperature at the beginning of the discharge duty cycle shall be assumed to be [___]°F ([___]°C). Each battery shall operate for a [10-year] [___-year] rated life. Each battery shall perform in accordance with the requirements of its respective duty cycle at any time, including at time of delivery and when the battery has reached its rated life.

***ATTENTION:***
***Indicate below required capacity at time of delivery. If 100 % capacity is required, this requirement costs additional money and actually reduces battery life by a few cycles. If the proper aging factor has been used in sizing the battery then 100% capacity at delivery is not required. If the installation is for a short-term application where sizing was based on design and aging factors of 1.0, then 100% capacity may be required. For many applications 90% capacity at time of delivery is sufficient. As the battery string cycles, its capacity increases eventually reaching 100%.***
**********

3.2.3 Capacity. Batteries shall be greater than or equal to [90%] [100%] [___%] rated capacity at the time of delivery.

3.2.4 Charging cycle. The batteries shall be assumed to be fully charged and stabilized at the open-circuit voltage specified in Seller's proposal (see Appendix B) just prior to commencement of the duty cycle. During normal operation, each battery shall be continuously float-charged by its battery charger.

***ATTENTION:***
***Include the following only if a battery charger is required (not necessary for UPS applications.) Enter the desired length of the recharge time following a discharge in paragraph 3.2.5, below. Note that two different discharges are specified. One is based on the normal system load profile specified in Appendix B, the other one is based on a deep discharge resulting from a capacity test. Enter the system recharge voltage as well as the normal load current. It is recommended that valve-regulated type batteries be recharged at their float-voltage rating (2.25 V/cell) in order to reduce the possibility of thermal runaway. This information is required so that the battery vendor can provide data for the recommended battery charger. The normal recharge time for a reasonable size charger is 1.5 to 2.0 times the discharge time.***
**********

3.2.5 Recharge time. The desired recharge time to 95% rated capacity is [72] [___] hours following a discharge based upon the duty cycle, and [72] [___] hours following a performance-test discharge in accordance with IEEE 450. Charging shall be accomplished at [2.25] [___] V per cell. [Normal DC-system load current is [___] A exclusive of charging current.]

***ATTENTION:***
***Select the appropriate method: the constant current method is appropriate for general purpose; the kilowatt method should be used for UPS.***
**********

3.2.6 Battery sizing. The following additional sizing factors for the specified service conditions shall be based on the [constant current method in accordance with IEEE 485.] [kilowatt method.]

***ATTENTION:***
***Supply the appropriate factors below. The temperature correction factor is obtained from IEEE 450. This number ensures that the battery has sufficient capability at the coldest expected temperature. Do not use a correction factor of less than 1.0. The design margin factor for general purpose is normally 1.10 to 1.15 to allow for future system growth. The design margin factor for UPS application is normally 1.0 based on the assumption that the UPS cannot be loaded by more than 100%. The normal aging factor for either application is 1.25, which is consistent with retiring the battery when the battery can no longer supply above 80% of rated capacity. For pure lead cells, aging factor is 1.0 since these cells maintain 100% (or better) capacity over their design life.***
**********

a. Temperature correction factor of [1.0] [___]

b. Design margin factor of [1.10] [___]

c. Aging factor of [1.25] [___] in accordance with IEEE 485

***ATTENTION:***
***Consult with the onsite structural engineer and DOE natural phenomena protection standards regarding seismic requirements for the specific site. Revise or delete all of paragraph 3.2.7 as necessary.***
**********

3.2.7 Seismic requirements.

3.2.7.1 Seismic qualifications.

***ATTENTION:***
***Delete this paragraph if rack is not to be provided. Enter the seismic requirements for the battery site using the appropriate building code.***
**********

a. The battery [rack] [cabinet] furnished shall be certified for seismic zone [___,] such that the battery can perform its intended function during and after a seismic event.

***ATTENTION:***
***Include the following paragraph if equipment structures are intended to be completely self-supporting (except cells).***
**********

b. Design equipment and equipment supports to withstand and maintain their structural integrity when exposed to seismic loading indicated above. The equipment structures shall be completely self supporting.

c. Support design shall not include friction for resisting the lateral shear load.

d. The maximum stresses, under seismic loading combined with all other load effects, shall be within the normal allowable material working stress limits as set forth in the appropriate references listed in this specification.

e. Investigate any deformations resulting from the combined influence of normal-operating loads and seismic loads, to verify they will not impair structural integrity.

3.2.7.2 Demonstration of integrity. Demonstrate the equipment's ability to withstand and maintain its structural integrity when subjected to the forces resulting from the seismic conditions specified. This shall be accomplished in one or a combination of the following methods:

a. Predict the equipment's performance and response to a seismic force by mathematical static analysis;

b. Test the equipment under simulated seismic conditions (static or dynamic testing); and/or

c. Utilize previous seismic certification of the equipment [or equivalent equpment if equivalence can be demonstrated,] and demonstrate applicability under the seismic conditions specified.

***ATTENTION:***
***The following subparagraph reflects seismic requirements under the Uniform Building Code (ICBO UBC.) Revise as required under other building code jurisdictions.***
**********

3.2.7.3 Seismic loading method. The seismic loading on the equipment and its supports shall be obtained by multiplying the weight of the components by the horizontal seismic acceleration coefficient (H) in accordance with the following three options. The force shall be assumed to act in any lateral direction, combined with 0.15 W uplift or downward acceleration due to earthquake in accordance with ICBO UBC. (Note: Z = seismic zone factor, I = site coefficient, and Cp = horizontal force factor)

***ATTENTION:***
***In the following options, adjust the Z, I, and Cp factors as required for the specific project.***
**********

- Option one. If the equipment is supported on walls, on the roof, or from the roof of the building, use:

  H = 0.75 (Based on Z = 0.5, I = 1.0, and Cp = 2 x 0.75)

- Option two. If the equipment is flexible and supported on legs and is anchored directly to the existing concrete slab on grade, use:

  H = 0.50 (Based on Z = 0.5, I = 1.0, and Cp = 2 x 0.67 x 0.75)

- Option three. If the equipment is designed as a rigid box without support legs and is anchored directly to the existing concrete slab on grade, use:

  H = 0.375 (Based on Z = 0.5, I = 1.0, and Cp = 0.75)

3.2.7.4 Review documents.

a. Submit for Owner review, all design drawings, structural calculations, and test results utilized for seismic qualifications of the battery racks, including appropriate anchorage calculations and details.

***ATTENTION:***
***For seismically-rated racks, include the following paragraph and select the appropriate engineer and state licensing required.***
**********

b. Design drawings and calculations submitted shall be stamped and signed by a [civil or] structural engineer currently registered to practice in the State of [_____.]

3.3 Design and construction.

3.3.1 Materials. All materials shall be new and selected to perform as specified. Like parts shall be interchangeable. Workmanship shall be neat, comply with recognized industry standards, and be in accordance with accepted engineering practices. All connectors and terminal details shall be lead-plated copper. All connector hardware such as bolts, washers, and nuts shall be type 316 stainless steel.

3.3.2 Battery Type.

a. Batteries shall be of the sealed valve-regulated type. They shall be the [absorbed (starved) glass mat] [gelled-electrolyte] type, operating on an oxygen-recombination cycle. All cells shall be completely assembled and shall be shipped in accordance with Section 7.

***ATTENTION:***
***In the next paragraph, enter the desired positive-plate type. Plate type shall be lead calcium or lead antimony. Most manufacturers add a doping agent such as selenium or arsenic to produce the desired battery characteristics. Consult the battery manufacturer for details.***
**********

b. Batteries shall be of the [lead-calcium] [lead-antimony] alloy type, with positive and negative plates of Seller's standard design. Active material for the positive plates shall be lead dioxide, and for the negative plates shall be sponge lead. Active materials shall be retained in structures designed to retard corrosion and withstand over-charging. Negative plates shall have a life equal to or greater than that of positive plates.

3.3.3 Cell features.

a. Each cell element shall be in a fire-retardant, high-impact plastic jar and cover. The jar and cover material shall have a limiting oxygen index (LOI) of at least 28%.

b. Heat seal, cement or otherwise fasten cell covers to containers to form a leakproof and gas-tight seal, and fit with a pressure-relief vent to relieve excess pressure.

c. Design cells to accommodate plate growth such that the jar and cover will not crack.

***ATTENTION:***
***Enter the appropriate cell voltages below. The float voltage depends on the plate alloy and specific gravity selected. Refer to the battery manufacturer's recommended values. The equalization voltage and the minimum discharge voltage are normally determined from the maximum and minimum input voltage ratings of the UPS/connected system.***
**********

d. All cells shall be suitable for float at [2.25 V] [___ V] per cell and equalize at [2.25 V] [___ V] per cell. The minimum discharge voltage shall be [1.75 V] [___ V] per cell.

e. Support plates so that no undue stress is placed on the jar or cover during the life of the battery. Negative and positive plates shall be matched. Reinforce the plates as needed to retain their shape and maintain the low internal resistance necessary to carry the current to or from all parts of the plate under all operating conditions. Separators shall be impervious to the chemical action within the cell, and shall provide proper spacing and insulation between the plates to permit free circulation of evolved oxygen.

f. The individual cells or containers shall be suitable for mounting in either stacked modules or standard racks. Stacking of cells horizontally shall have no effect on cell integrity or performance.

***ATTENTION:***
***Delete paragraph 3.3.4 if the services of the Seller as listed in paragraph 1.3 do not require the installation of a rack.***
**********

3.3.4 [Battery racks.] [Battery cabinets.]

***ATTENTION:***
***Enter the desired type and number of tiers. This selection may depend on space available, but should not exceed two tiers. Step tiers are preferable for ease of maintenance, provided space is available. The maximum acceptable height of the racks shall be 50 inches (1.2 m) from the floor to the top of the battery jar located on the second tier. For racks greater than 50 inches (1.2 m) in height, contact the local authority having jurisdiction, as these become a problem for the following reasons:***

- ***Difficult and unsafe to maintain***
- ***Temperature differences between cells***
- ***Seismic integrity***

**********

a. Provide [battery racks] [self-contained cabinets] made of steel, properly insulated and coated in accordance with paragraph 3.6.1. The paint shall resist the corrosive effects of the battery electrolyte, resistant to 93% sulfuric acid in immersion duty. The [racks] [cabinets] shall be of the [2-tier] [2-step] [_____] type, complete with all necessary steel frames, fittings, rails and braces, plastic insulating channels, plastic spacers and hardware. [Provide earthquake-rated hardware.]

b. The [racks] [cabinets] shall permit battery mounting in the rooms shown on [Sketch No. ___] [Drawing No. ___] (Attachment 1) and shall permit easy battery maintenance. Provide a minimum of 14 inches (350 mm) clearance from the top of the battery-jar terminal posts to the bottom of the [rack] [cabinet] above.

c. Each [rack] [cabinet] shall have a ground-loop connection point and a lead-plated ground terminal lug from Seller's standard manufacturer for the Owner's ground conductor.

***ATTENTION:***
***Select the following paragraph d. if ordering battery cabinet and if the room in which the battery cabinet will be located does not have adequate cooling.***
**********

d. The battery cabinet shall be equipped with a nonferrous, nonsparking fan system capable of providing the proper number of air changes per hour and limit the hydrogen concentration to less than 25% LEL (lower explosive limit). All fan components shall be grounded for spark resistance.

e. Where [racks] [cabinets] are shipped unassembled, number or match-mark all parts to facilitate field assembly and provide installation instructions.

***ATTENTION:***
***Include the following paragraph if applicable.***
**********

e. [Racks] [Cabinets] and anchorage shall be seismic rated as indicated in paragraph 3.2.7.

3.3.5 Terminals and connectors.

a. Connectors shall meet the requirements of UL 486A or comparable standard by any nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7.

b. Clearly mark each cell post for permanent identification of polarity, and seal to the cover.

***ATTENTION:***
***Select 15-minute rating for UPS applications, 3-hour for general-purpose.***
**********

c. Provide [lead-plated copper bus bar] [_____] connectors for connecting the jars in series. All connecting [bus] [straps] and hardware shall be able to carry the [15-minute] [3-hour] [_____] rating of the battery, or a continuous current equal to the battery's end-of-discharge voltage of [1.75 V] [___ V] per cell, whichever provides the higher current-carrying capability. This shall be accomplished without exceeding a temperature rise of 30°C above ambient. Provide insulated cable connectors between [tiers] [steps] and between jars on different [rack] [cabinet] sections where the sections are located adjacent to each other, or back-to-back. Arrange cable on the [racks] [cabinets] to prevent external mechanical damage. Provide details of copper terminal connectors that are completely lead-plated.

***ATTENTION:***
***Coodinate the selection of agent in the following paragraph with the scope of work specified in paragraphs 1.2 and 1.3.***
**********

d. The [Owner will] [Seller shall] provide the cable interconnections between the battery string (positive and negative terminals) and the battery charger. The [Owner will] [Seller shall] also provide the inter-rack and inter-tier cabling where rack sections are not arranged end-to-end or back-to-back. Provide [2-hole] [4-hole] [__-hole] compression-type lead-plated connectors sized to accommodate [Owner] [Seller] cables in sizes specified below. Provide multi-cable terminal connections for each connection.

***ATTENTION:***
***Enter the cable and terminal lug information for the Owner's interface hardware. If the type of lug supplied is not critical, delete the following two sentences and enter "Seller's standard" in the above paragraph. Specify type ground conductor to be used.***
**********

- Owner's connecting power cable is [___] [AWG] [kcmil] size, [diesel locomotive] [___] type; with [2] [___] cables per positive and negative pole.

- Owner's ground conductor for battery rack is [___] [AWG] [kcmil] size; [bare copper.] [_____ type.]

e. Interjar connectors supplied shall in no way affect installation of the flame-arrester vents provided with the cells.

f. For jars mounted on the same [tier] [step] of a battery rack, provide inter-jar connectors of adequate length to allow an air space of approximately 1/2 inch (13 mm) between jars.

***ATTENTION:***
***Coordinate the following paragraph with the scope of work specified in paragraph 1.3 "Work to be Provided."***
**********

3.4 Accessories. Furnish and ship with each battery, any and all accessories essential for proper installation, operation and maintenance. Accessories include the following:

a. Cell numbers from "1" to highest cell number for each battery cell, and positive (+) and negative (-) sign labels, with provision for permanent field mounting on cell jars or [racks.] [cabinets.] Seller shall also provide battery [rack] [cabinet] number labels as noted on the attached [drawings.] [sketches.] The cell and battery [rack] [cabinet] number labels shall be corrosion resistant.

b. Protective grease such as "No-Ox-Id" by Sanchem, Inc. or manufacturer-recommended alternate for connections.

c. Touch-up paint for battery [racks] [and] [cabinets].

d. Two insulated socket wrenches for connector bolts.

e. Battery-post insulators to cover all battery post and intercell connectors. Covers shall be made of a clear material meeting UL 94 flame-spread requirments, and shall have an LOI rating of 28% or greater.

***ATTENTION:***
***Coordinate weight limitation with onsite safety restrictions.***
**********

f. Cell lifting device and spreader where cells, including multiple cell units, weigh 50 lb (22.5 kg) or more.

g. Two insulated socket wrenches for connector bolts.

3.5 Spare parts and special tools.

3.5.1 Spare parts. Provide a list of recommended spare parts, identifying each one and the specific subassembly to which it applies. Indicate the expected life of the parts requiring replacement and the minimum recommended inventory of spare parts for installation startup, continuous operation, and maintenance. State whether the recommended spare part is a stock or special-order item, provide the name and location of the nearest supplier, and indicate approximate lead time required for delivery.

3.5.2 Spare Accessories Furnish and ship with each battery, the following:

***ATTENTION:***
***Select appropriate number of spare jars, depending upon application.***
**********

a. Extra battery jars ([10% of total required by UPS manufacturer] [[___] for general-purpose application])

b. Extra cell bolts, washers, and nuts (10%) and extra intercell straps (5%) with a minimum of two straps

3.5.3 Special tools. Furnish all special tools necessary for installation, startup, operation, maintenance, and adjustment of the equipment and of the accessories provided. Provide a list of all special tools furnished, identifying the function of each tool and the specific items for which it is used. Furnish insulated tools where required.

3.6 Surface preparation and coatings.

3.6.1 Corrosion protection. Select a coating system for the steel battery [racks] [cabinets] to provide corrosion protection during shipment, storage, and operation in the environment indicated in paragraph 3.2.1. The coating system provided shall resist the corrosive effects of the battery electrolyte, resistant to 93% sulfuric acid in immersion duty. Stainless steel, galvanized, bronze and other nonferrous surfaces will not require coating.

3.6.2 Steel treatment. Steel surfaces shall receive Seller's standard treatment prior to application of the coating system.

3.6.3 Color. Primer and top coat materials shall be by the same manufacturer. Final color shall be [manufacturer's standard light gray.] [_____.]

3.7 Equipment marking.

***ATTENTION:***
***Include optional method of marking, if desired.***
**********

3.7.1 Nameplate. Provide a corrosion-resistant nameplate with clearly legible writing for each jar, in an easily visible place. It shall provide all necessary information pertaining to the equipment but, as a minimum, include the following: manufacturer's name, type of battery cell, manufacturer's type designation, nominal electrolyte specific gravity at 77°F (25°C) and date of manufacture. [Alternately, the date of manufacture may be stamped on one of the jar posts.]

3.7.2 Polarity markings. For each battery cell, the positive posts shall be marked either with a positive sign (+) or letters "POS." Negative posts shall carry a negative sign (-) or the letters "NEG."

***ATTENTION:***
***Where applicable, include the following paragraph and enter the seismic zone number for the battery installation.***
**********

3.7.3 Seismic qualification marking. Mark each rack "Zone [___]."

***ATTENTION:***
***Revise scope of field services as appropriate, depending on who does the installation.***
**********

3.8 Installation. The [Owner will] [Seller shall] install the batteries. [Provide the services of a field-service representative to provide technical advice for installation and startup. Scope of services shall be clearly stated in Seller's proposal in accordance with Appendix A.] Provide adequate information covering installation requirements in time for Owner's use (see paragraph 4.4).

***ATTENTION:***
***Include the following paragraph if an annual maintenance contract is required. Coordinate with Appendix A requirements.***
**********

3.9 Maintenance. Submit with the proposal a quotation for the annual maintenance of each battery string. Include details of the maintenance work, testing and record-keeping performed as a part of the maintenance contract. Submit with the proposal a typical example of a maintenance report for a similar maintenance contract.

4. DOCUMENTATION

4.1 General.

a. Submit the drawings and data required by the specification and/or listed in paragraph 4.2 within the time specified for Owner's review.

b. The Owner's general review of drawings and data or waiver of same shall in no event relieve Seller of any responsibility to meet all requirements of this specification or the purchase order.

4.2 Drawings and data. Submit the following for Owner review:

a. Drawings showing batteries, interconnections, [rack] [cabinet] outlines, dimensions required for mounting, weight of [racks] [cabinets] and filled cells, and description of [rack] [cabinet] finish for each battery system

b. Cell outline including connector and battery terminal details, electrolyte levels, weight of assembled cell, separate weights of electrolyte, plates, and jar

***ATTENTION:***
***Add the following paragraph when seismic requirements apply.***
**********

c. Seismic rack design and certification (see paragraph 3.2.7)

d. Type, catalog designation, and description of major components provided by Seller

e. Longest recommended storage time when batteries are shipped charged, and Seller's storage and freshening charge recommendations

f. Field test recommendations, including performance tests

g. Test reports for factory tests, including capacity tests

4.3 Instruction and maintenance manuals. Provide in the manner, number of copies, and within the time limits, as set forth in the purchase order, instruction manuals in accordance with the Owner's requirements. One copy of the instructions applicable to each component or group of components, if there are no differences, shall be shipped with the component(s).

4.4 Data submission schedule.

| *ITEM* | *DESCRIPTION* | *SPEC PARA* | *SELLER'S SUBMITTAL DATE* | *OWNER'S REVIEW REQUIRED BEFORE SHIPMENT* |
|---|---|---|---|---|
| a. | Preliminary drawings & data sufficient for Owner to evaluate equipment | App. A | With proposal | Yes |
| b. | Completed data forms | App. B | With proposal | Yes |

| *ITEM* | *DESCRIPTION* | *SPEC PARA* | *SELLER'S SUBMITTAL DATE* | *OWNER'S REVIEW REQUIRED BEFORE SHIPMENT* |
|---|---|---|---|---|
| c. | Complete list of codes & standards equipment meets | App. A | With proposal | Yes |
| d. | Complete list of exceptions | 5.4 & App. B | With proposal | Yes |
| e. | Recommended spare parts list | 3.5 & App. A | With proposal and shipment | Yes |
| f. | List of special tools | 3.5 & App. A | With proposal and shipment | No |
| g. | Final drawings & data | 3.2.7 & 4.2 | [4] [___] weeks before shipment | Yes |
| h. | Installation & maintenance instructions/ manuals | 4.3 & App. A | With proposal & [4] [___] weeks before shipment | No |
| i. | Fabrication sequence | 5.3 | [2] [___] weeks before fabrication | No |
| j. | Seller's recommended instructions for long-term storage | 7.2.h | [4] [___] weeks before shipment | No |
| k. | Storage and handling instructions | App. A | [4] [___] weeks before shipment | No |
| l. | Factory test results | 6.2 | [2] [___] weeks before shipment | Yes |
| m. | Certificate of compliance | 5.5 | With shipment | No |
| n. | Quality assurance (QA) documents | 5.5 | With shipment | No |

5. QUALITY ASSURANCE

5.1 General. Seller shall have methods to assure that items and services, including subcontracted items and services, comply with this specification.

5.2 Owner surveillance. Manufacturing, processing, testing and inspection operations affecting the equipment or material shall be subject to surveillance by the Owner.

5.3 Fabrication sequence. Prior to production, submit a fabrication sequence describing inspection and/or tests to be performed, for use in determining inspection points which the Owner may desire to witness. The Owner will advise Seller, prior to production, of those fabrication steps and shop inspection points that the Owner desires to witness. Seller shall give the Owner adequate notice, at least 5 working days, prior to those fabrication steps and tests which the Owner desires to witness.

5.4 Deviations. All deviations to this specification shall be documented and referred to the Owner for disposition.

5.5 QA documentation. Provide the following quality assurance (QA) documents for the Owner's records:

a. Certificate of compliance, stating the following: "All work provided by Seller under this specification complies with all requirements of this specification and Owner-accepted deviations."

b. Documents identifying deviations and their acceptance.

6. INSPECTION AND TESTING

6.1 General.

6.1.1 Purpose of tests. Factory and field tests shall be conducted to determine the materials and work are free from defects, and to establish design and construction meet the requirements of this specification and the purchase order. Owner acceptance of the equipment shall not relieve the Seller of responsibility for meeting all the requirements of this specification.

6.1.2 Expense of testing. The cost of equipment, instruments, tools, personnel and other expenses incidental to the tests, including replacement of damaged materials and subsequent retests, shall be borne by Seller. This does not include Owner's expense in witnessing the tests.

6.1.3 Failed tests. If the battery system or any part of it fails to meet the specified performance guarantees, correct/rework or replace the part which fails, as mutually agreed with the Owner.

6.1.4 Tests results. Submit test results for Owner review.

6.2 Shop tests.

***ATTENTION:***
***The following paragraph is optional depending on battery use.***
**********

6.2.1 Pilot cell. Designate a pilot cell on the basis of the test results for each battery system's permanent record. With the battery shipped wet, it shall be the cell with the lowest voltage after the battery is charged.

***ATTENTION:***
***Enter acceptable tolerances in subparagraphs a and b, below. A ± 40 mV deviation from nominal volts per cell (Vpc) is the normal maximum tolerance for lead-calcium cells. Lead antimony cell tolerance is normally ± 20 mV. Specific gravity tolerance is normally +/- 10 points.***
**********

6.2.2 Production tests. Perform the following production tests at the factory:

6.2.2.1 Cell voltage measurement. The tolerance shall be ± [40 mV] [___ mV] from a nominal [2.25] [___] V/cell.

6.2.2.2 Pressure-relief vent operation and reseal. Shall pass manufacturer's standard test.

6.2.2.3 Cell-jar leakage test. The cell shall be pressurized with air and the pressure shall remain constant.

6.3 Field tests. The Owner will perform a battery performance test in accordance with IEEE 450 on the fully-assembled batteries at the job site. The test will be based on the battery manufacturer's ampere-hour rating of the battery. Seller may attend this test as noted in Appendix B, paragraph 8.

7. PREPARATION FOR DELIVERY

***ATTENTION:***
***Enter all shipping instructions. Batteries should be shipped wet and fully charged. It may be advantageous to ask for special packing to facilitate handling the components when received, or grouping parts in a way that facilitates installation. Special shipping instructions may also include a dedicated truck to expedite delivery.***
**********

7.1 Cleanliness. At the time of shipment, the equipment shall be clean inside and outside. Remove all rust, oil, grease (except corrosion-inhibiting compound on cell posts), chalk, crayon, and paint marks, and other deleterious material from all surfaces of the equipment. Touch up any cuts, nicks, or scratches to the coating system.

7.2 Preparation for shipping and storage.

a. Prepare equipment for shipment to protect it from damage during shipment and subsequent storage.

b. Protect all openings to prevent damage, corrosion, and entrance of foreign matter during shipment and storage.

c. Adequately support equipment for shipment. Crate or box loose parts for shipment, appropriately identified.

d. Label and number packaging so that each section or assembly may be identified before being uncrated.

***ATTENTION:***
***When selecting a suitable storage period below, use six months for lead calcium and three months for lead antimony.***
**********

e. Ship each cell wet and charged, and filled with electrolyte. Batteries that are shipped charged shall be suitable for storage for a period of at least [three] [six] months without the need for charging.

f. The Owner will provide a storage environment similar to the installation location.

g. Provide storage and handling instructions including descriptions for periodic inspections and/or storage maintenance to assure that no deterioration will occur during storage. Securely fasten one set of these instructions to the outside of the shipping unit.

h. Provide recommended instructions for long-term storage.

**END OF SECTION**

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## APPENDIX A
## ADDITIONAL TECHNICAL REQUIREMENTS

A.1 Drawings and Data. Provide with the proposal, the following drawings and data:

a. Sufficient illustrative and descriptive material to allow a detailed evaluation of the equipment being proposed. Seller-provided data shall indicate the guaranteed performance data, predicted performance, interface characteristics, installation instructions, and construction features of all Seller-provided equipment. The accuracy of such information and the compatibility of such information with overall performance requirements specified by the Owner, are the sole responsibility of Seller.

b. Preliminary general assembly drawing(s) indicating approximate overall dimensions and clearances needed for operation and maintenance or a statement that Owner's battery room dimensions are satisfactory to accommodate the battery string. Indicate the minimum required clearances between battery [racks,] [cabinets,] between battery [racks] [cabinets] and other equipment/structures, and the vertical clearances for installation.

c. Completed data sheets included in Appendix B. If a "base" and an "alternate" system are proposed, these sheets shall be copied and completed for each system. The words "base" and "alternate" shall be marked on the appropriate sheets.

d. Complete listing of codes and standards referenced in Section 2.0 which the battery system meets.

***ATTENTION:***
***Include the following paragraph if an annual maintenance contract is required. Coordinate with paragraph 3.9.***
**********

A.2 Maintenance Subcontract. Submit a quotation with the proposal for annual maintenance of the batteries. Include details of the maintenance work, testing, and record keeping to be performed as a part of the maintenance subcontract. Submit with the proposal, a typical example of a maintenance report for a similar or equal battery system.

A.3 Warranty. Provide with the proposal, complete details of the warranty to be provided for the battery, battery [racks,] [cabinets,] and accessories.

a. Provide the value of each battery for warranty purposes in determining a short-life adjustment.

b. Provide a formula for calculating the pro-rated credit to be given to the Owner towards the purchase of a new battery for cases where a battery fails before its guaranteed useful service life.

c. Provide an example to illustrate how the credit will be computed.

A.4 Experience. Provide a complete list of (not less than three) installations of similar nature within the past five years as detailed below:

| *ITEM NO.* | *CLIENT* | *CONTACT PHONE* | *ADDRESS* | *DATE SOLD* | *DATE INSTALLED* |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |

**END OF APPENDIX A**

## APPENDIX B
## BATTERY SYSTEM DATA SHEETS

1. General Data.

   a. Battery String Designation — No. [1] [___]

   b. Battery Type:

   - Grid alloy: Pure lead (PB), lead calcium (LC), lead antimony (LA), or lead selenium (LS) — _____
   - Cell type: Absorbed glass mat or gel cell — _____
   - Seller's type number — _____
   - Number of positive plates per cell — _____

   c. Does each battery and battery [rack] [cabinet] meet the seismic requirements outlined in paragraph 3.2.7? — *[Yes] [No]*

   d. Determination of Required Battery Capacity:

   - Method used to calculate battery capacity — _____
   - Provide description and calculation sheet for battery string. (Calculation sheet attachment number) — _____

   e. Manufacturer's Warranted Life of Battery — _____ Yrs

f. Recommended Battery Charger Data (paragraph 3.2.5):

- Floating voltage range _____ V
- Equalizing voltage range _____ V
- Current rating _____ A
- Recharge time _____ hr

g. Estimated salvage value of each battery at end-of-life at the current market price

$_____

h. Heat Released During:

- Discharge duty cycle _____ BTU/hr (W)
- Float charge _____ BTU/hr (W)
- Equalizing charge _____ BTU/hr (W)

i. Maximum Amount of Hydrogen Gas Evolved During Battery-Equalizing Charge (2.33 V per cell) at Maximum Battery Temperature _____ cu ft/hr ($m^3$/h)

j. Hydrogen Gas Evolution at Float _____ cu ft/hr ($m^3$/h)

k. Time Battery may be Stored Without a Freshening Charge _____ months

l. Temperature Compensation Required *[Yes] [No]*

2. Physical Description.

a. Battery Cell:

- Size (L x W x H) ___ x ___ x ___ inches (mm)
- Weight _____ lb (kg)
- Volume of electrolyte _____ gal (L)
- Jar cover material _____
- Jar container material _____
- Separator material _____
- Retainer material _____
- Limiting-oxygen index (LOI) _____

b. Battery [Rack] [Cabinet]:

- Outline or catalog number _____
- Quantity of [racks] [cabinets] for the battery _____
- Description (tier or step type) _____

c. Total Net Weight of Battery Including [Racks] [Cabinets] _____ lb (kg)

d. Total Shipping Weight of Each Battery Jar and Associated Equipment _____ lb (kg)

e. Provide Drawing of Assembled Battery, Including [Rack] [Cabinet] Dimensions (sketch attachment number) _____

f. Connectors:

- Intercell:
  - Type _____
  - Material _____
  - No. per connection _____
- Inter-[Tier] [Step]:
  - Type _____
  - Material _____
  - No. per connection _____
- Terminal Detail:
  - Type _____
  - Material _____

g. Terminal Lugs for Owner's Power Cable:

- As specified by Owner in paragraph 3.3.5.e *[Yes] [No]*
- Manufacturer _____
- Type No. _____

h. Terminal Lugs for Owner's Ground Conductor:

- As specified in paragraph 3.3.5.e *[Yes] [No]*
- Manufacturer _____
- Type No. _____

| i. Torque Data: | ***Initial Torque Value*** | ***Retorque Value*** |
|---|---|---|
| ● Intercell Connectors | _____ in-lbf (J) | _____ in-lbf (J) |
| ● Inter-[Tier] [Step]: | | |
| ● Terminal detail to post | _____ in-lbf (J) | _____ in-lbf (J) |
| ● Cable connection to terminal detail | _____ ft-lbf (J) | _____ ft-lbf (J) |
| ● Main Leads: | | |
| ● Terminal detail to post | _____ in-lbf (J) | _____ in-lbf (J) |
| ● Cable connection to terminal detail | _____ ft-lbf (J) | _____ ft-lbf (J) |

3. Performance Data.

| | |
|---|---|
| a. Battery String Designation | No. [1] [___] |
| b. Float Voltage Without Equalizing | _____ V/cell |
| c. Float Voltage With Equalizing | _____ V/cell |
| d. Equalizing Charge Voltage | _____ V/cell |
| e. Recommended Frequency of Equalizing Charge | _____ |
| f. Recommended Duration of Equalizing Charge | _____ |
| g. Open-Circuit Voltage | _____ V/cell |
| h. Short-Circuit Current at Short-Circuited (bolted) Battery Terminals at Float Voltage at 77°F (25°C): | _____ |
| i. Battery Discharge Characteristics (in A or A/positive plate) | _____ |

j. Guaranteed Amp-Hour Capacity (at the 8-hr rate) to Specified Final Voltage (paragraph 3.1):

- One-minute _____ A/cell
- Fifteen-minute _____ A/cell
- One-hour _____ A/cell
- Three-hour _____ A/cell
- Eight-hour _____ A/cell

4. Environmental Considerations. In accordance with paragraph 3.2.1, the operating environment for this installation *[will] [will not]* affect the life expectancy of the components used in this equipment. If there will be an effect, the following components will be affected as listed below:

| ***COMPONENT*** | ***EFFECT*** |
|---|---|
| _____ | _____ |
| _____ | _____ |
| _____ | _____ |

5. Accessories. In accordance with paragraph 3.4, accessories furnished by Seller for each battery include:

_____

_____

_____

_____

6. Spare Parts. The following spare parts are recommended by Seller for each battery in accordance with paragraph 3.5:

_____

_____

_____

_____

7. Special Tools. In accordance with paragraph 3.5, special tools furnished by Seller include:

_____

_____

8. Tests. If the Owner requests a battery performance test in accordance with paragraph 6.3, Seller *[will] [will not]* attend the test for each battery.

9. Delivery.

| | ***DELIVERY DATE/ LEAD TIME*** | ***METHOD OF SHIPMENT (e.g. truck, rail)*** |
|---|---|---|
| Battery No. [1] [___]: | _____ | _____ |

10. Warranty. For the purpose of determining a short life adjustment in accordance with paragraph A.3, the value of the battery string is as follows:

Battery No. [1] [___]: $_____

**END OF APPENDIX B**

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## APPENDIX C
## DEFINITIONS OF TERMS

**Absorbed Glass Mat** — A highly absorbent glass or polymeric fiber mat used to contain dilute sulfuric-acid electrolyte in absorbed glass-mat type batteries. These batteries have approximately 70% of the volume of a comparable flooded-cell battery, so contain a higher concentration of sulfuric acid (approximate SG = 1.300) to ensure that sufficient acid is available for reaction. (Otherwise known as a "starved-gel" cell.)

**Aging Factor** — A factor used to ensure that a battery will meet its duty cycle requirement upon initial installation and at its end-of-life. It is common for batteries to deliver 90 to 95% of rated capacity upon delivery. Capacity eventually rises to 100%, stabilizes there for a period of time, then starts to decrease to 80%. Capacity drops rapidly after reaching 80%, so 80% is assumed to be the point at which the battery should be replaced. The aging factor used would then be 1.25 (1/80%).

**Battery** — Two or more cells electrically connected to form a unit. Under common usage, the term also applies to a single cell.

**Cutoff Voltage** — Cell or battery voltage at which the discharge is terminated. The cutoff voltage is specified by the manufacturer and is a function of discharge rate and temperature. (Also called end-of-duty cycle voltage.)

**Design Margin Factor ($k_d$)** — Used to compensate for spare or excess capacity for future loads. The design margin factor can be assumed to be 1.0 for UPS applications where the battery system is sized for full capacity of the inverter. For general-purpose applications, the design margin factor can range from 1.10 to 1.25.

**Duty Cycle** — The load currents a battery is expected to supply for a specified time period.

**End-of-Duty Cycle** — See "Cutoff Voltage."

**Equalizing Charge** — Charge applied to a battery which is greater than the normal float charge which is used to completely restore the active materials in the cell, bringing the cell float voltage and the specific gravity of the individual cells back to "equal" values.

**Float Charge** — Method of charging in which a secondary cell is continuously connected to a constant-voltage supply that maintains the cell in a fully-charged condition.

| | |
|---|---|
| **Gel Cell** | The gel cell uses a silica added to the electrolyte to form a gel which liquifies above some fixed stress level, and converts back into a gel when left standing. Only the electrolyte between and around the plates will gel. The electrolyte in the pores of the plates and microporous separators remains liquid. |
| **Grid Alloy** | Material composition of the positive plate, such as lead calcium, lead antimony, or lead selenium. |
| **Grid Growth** | Increase in dimension of lead-battery plates caused by oxidation of metallic lead grids into lead dioxide, which consumes more volume. |
| **Harmonics** | A sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency. For example, a third harmonic is equivalent to three times the fundamental frequency. |
| **Insulated Tool** | A tool or device which has conductive parts and is either coated or covered with a dielectric material. |
| **Limiting Oxygen Index (LOI)** | The flammability index of the plastic material used in the construction of the battery jar. LOI ratings of 28 or greater are desirable due to the plastic's ability to withstand fires rather than contribute to them. |
| **Pilot Cell** | A selected cell whose condition is assumed to indicate the condition of the entire battery string. The pilot cell is usually selected for representative measurements for a select period of time. Once this time period has elapsed, another cell from the battery string is selected in turn to be the pilot cell. |
| **Positive Plate Construction** | The grid and active material from which current flows to the external circuit when the battery is discharging. The positive plate can be composed of pure lead or a lead alloy such as calcium, antimony, or selenium. |
| **Sealed Valve-Regulated Type Battery** | Cell in which the internal environment is controlled and isolated from the external atmosphere, often by using some form of vent valve. Sealed cells often charge at above-ambient conditions to promote recombination. The electrolyte of a sealed valve-regulated type cell resembles petroleum jelly, versus a liquid solution as found in flooded-cell batteries. |

| | |
|---|---|
| **Separator** | Electrically insulating layer of material which physically separates electrodes of opposite polarity. Separators must be permeable to ions in the electrolyte, and may also have the function of storing or immobilizing the electrolyte. |
| **Specific Gravity** | Ratio of the weight of a solution to the weight of an equal volume of water at a specified temperature. Used as an indicator of the state of charge of a cell or battery. |
| **Temperature Correction Factor ($k_t$)** | A factor used to compensate for battery temperatures other than 77°F, which is the standard optimum rating for battery operation. At temperatures above 77°F, more capacity (ampere-hours) can be obtained from the battery, but battery life is reduced. At temperatures lower than 77°, less capacity can be obtained, but battery life is extended. Consult IEEE 450 for correction factors. |
| **Terminal** | External electric connections of a cell or battery, also referred to as "terminal post" or "post." |
| **Thermal Runaway** | Process in which a cell undergoes an uncontrolled rise in temperature due to the passage of increasing current (on short circuit discharge or constant-voltage charging and equalization). Chances of thermal runaway occurring can be reduced by utilizing a temperature-compensated charger with the battery system. If uncorrected, this condition can sometimes lead to fire and/or explosion. |
| **UPS** | Uninterruptible power supply; a system designed to automatically provide power when "normal" utility line power is lost, without delay or transients. |

**END OF APPENDIX C**

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## ATTACHMENT 1: [SKETCHES] [DRAWINGS] AND DIAGRAMS

[Sketch ___] [Drawing ___]: [Existing] [Proposed] Battery Room [___] Layout

Battery Duty-Cycle Diagram(s) [1 - ___ ]

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***ATTENTION:***
***Prepare and attach a sketch or drawing for each battery room. Existing conditions as well as proposed layout may be included for clarity. Identify each sketch or drawing by number and show the following information:***

- ***Room dimensions, including all required minimum clearances***
- ***Location of doors and windows***
- ***Location of other major system modules, including inverters and chargers.***

**********

**[SKETCH ___] [DRAWING ___] [EXISTING] [PROPOSED] BATTERY ROOM [___ ] LAYOUT**

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***ATTENTION:***
***For each battery, supply a complete description of the battery duty cycle. This normally takes the form of a diagrammed load list showing amperes versus time. All loads and the time at which they are present must be shown; this includes inrush currents, if any. Random loads whose time cannot be predicted must be listed; these should, for sizing purposes, be shown to occur at the worst-case part of the duty cycle. Refer to IEEE 485 for additional details.***
**********

**BATTERY DUTY-CYCLE DIAGRAM [1] [___]**

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## ATTACHMENT 2: TITLE PAGE (sample)

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**S P E C I F I C A T I O N** **PPS-XXXX**

*University of California*

**PLANT ENGINEERING**

***Title:***

*SEALED VALVE-REGULATED TYPE*
*LEAD ACID STORAGE BATTERIES*

_____
*Approved* **[.....]**

_____
*Checked* **[.....]**

_____
*Originated* **[.....]**

***CONTENTS***



***ATTENTION:***
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# DOE-SPEC-3019-96

## CONCLUDING MATERIAL

**Review Activity:**

DOE
DP
EE
EH
EM
ER
FE
FM
HR
NE
NN
PO
RW

Field Offices
AL
CH
ID
NV
OR
RL
SF
SR
Fernald
Golden

National Laboratories
BNL
LLNL
LANL
ORNL
PNL
SNL

Area Offices
Amarillo
Kirtland
Los Alamos
Pinellas
Princeton
Rocky Flats

Operations Office
Idaho
Nevada
Oakland
Oak Ridge
Richland

**Preparing Activity:**

DP-31

**Project Number:**

6140-0002