SPECIFYING AND SIZING THE BATTERY

General

Many times, when a DC powered instrumentation or control system is being specified, a great deal of attention is given to specifying all parameters of the process system with little thought given to the battery or charger. Yet the entire system is useless if the battery does not power the load when needed.

In the majority of cases when a DC system fails, the battery has failed to perform. This could be the natural result of an old battery finally just "dying". In which case no one would be surprised, and in fact, good preventative maintenance would have identified the weak battery, allowing it to have been replaced before system failure. However, all too often the battery fails to provide its expected life because the conditions which cause premature battery failure are not recognized and addressed in the procurement phase.

Batteries are available today that have a Guaranteed/Warrantied life span of 90 days to 25 years. With this wide of product quality range, the pricing rage is greatly varied as well.

A brief description of the various battery types follows to provide a better understanding of the strengths and weaknesses relating to each particular battery type. There are four basic battery types being used with industrial float service applications today:

Battery Type	Guaranteed Life
Flooded Lead Acid	1-20 Years
Flooded Nickel Cadmium	1-25 Years
VRLA (Valve Regulated Lead Acid)	1-20 Years
Recombinant Nickle Cadmium	1-25 Years

Although not recommended for float service applications, a fourth type of battery is

sometimes used; the flooded vented lead acid SLI (Starting, Lighting and Ignition) battery.

The flooded vented lead acid (SLI) battery is either a standard automobile/truck battery or slightly modified derivative of the same. They are characterized by thin plates, high specific gravity electrolyte (1.260-1.275), high energy density and relatively short life (1-3 years). These batteries were designed to be charged from an automobile engine alternator. It was expected they would be thus charged 2-4 hours per day, every day as the vehicle is being driven; and when they are not being charged, they were expected to be sitting virtually open circuit with perhaps only a clock operating.

This type of operation is considerably different from that typically seen by a stationary battery. When placed in a constant float charge application, they experience unique problems. When charged at their desired voltage but in a continuous float application, they experience overcharge, excessive gassing, accelerated plate shedding and resulting shortness of life. When the float charging voltage is reduced to alleviate this overcharging, they suffer from under charge, plate sulfation and again, shortness of life.

We will address some optional features that can be specified on the charger to greatly improve the life of SLI batteries in float service. However, even with the best chargers, SLI batteries in float service will probably have shorter lives than an identical SLI battery in an automobile.

The flood vented lead acid stationary battery will last much longer than its SLI counterpart. Because it is designed for 10, 15, or even 20-year life, the plates are much thicker (less plate surface per pound of active material) and the specific gravity of the electrolyte is considerably lower (usually 1.215 – 1.240).

The flooded vented nickel cadmium batter is probably the longest life battery used in industrial applications. It is also perhaps, the most forgiving of all batteries in response to overcharge, undercharge, temperature extremes, vibrations and so on. It is also far above all other types in initial capital equipment cost. The nickel cadmium battery has a longer life, is a lower maintenance battery, and is much better as far as shock and vibration is concerned.

The VRLA battery is a float service stationary battery that was originally designed for short, fast discharges (10-15 minutes UPS applications and under one-minute switch gear applications). However today many manufacturers have expanded part of their product line to lend itself to long, slow discharge (communication) applications. The products designed for short, fast discharges are usually very good for Gen Set cranking. As with all lead acid batteries, care must be taken in applications involving

wide temperature ranges, especially high temperatures. The VRLA battery meets high shock and vibration specs, and some are virtually non-position sensitive.

The Recombinant Nickle Cadmium battery is basically a Nickel Cadmium version of the VRLA Battery. However, because it is of the Pocket Plate design, it is more immune to shock, temperature, and vibration problems.

As a supplier of all the above referenced battery types, we sincerely appreciate it when we see a specification which calls out our specific brand of batteries. However, as businessmen we are aware, we do have competitors.

It may not be your desire to write a battery specification around one specific supplier or type of battery, but instead to write a specification that would allow various types of batteries to be quoted.

Following are three different battery specifications for your consideration. One is specifically for stationary engine cranking applications. Another is for turbine starting, and the third is a general industrial specification.

In each specification, you may choose to specify a variety of the parameters, i.e. maximum and minimum temperatures, useful life, watering interval, etc. Or you may choose to leave certain of these blank and let each potential supplier provide you this information on their equipment to assist you in evaluating their quotes.

BATTERY SPECIFICATIONS

Engine Cranking:

The nominal_____VDC battery shall be designed for engine cranking service and shall be capable of cranking a _____ (cubic inch), _____ Make, _____ Model, _____ [Diesel or Gas] engine for _____ [#] each _____ Second cranking periods with_____seconds rest between cranks.

Assume a worst-case low engine cranking temperature of_____°F   (usually between 40- 90°F) and SAE_____oil   in   the crankcase.

Assume a worst-case low battery operating temperature of_____°F   Assume   a worst-case high battery operating temperature of_____°F

Assuming an average battery ambient temperature of_____°F,   and   a maximum of

_____ crank cycles per month, the system quoted will have a warranted useful life (will handle the load profile described) of__years "Full Replacement Guarantee", followed by_____years   "Prorated   Warranty"   while operating on an adequately sized charger to maintain the battery.

The   minimum   charger   size   recommended   by   the   battery   manufacturer   is
_____amps. The recommended "float" voltage is_____V/C,   =   _____VDC.   The recommended "Recharge" voltage is
_____ V/C, = _____VDC.

While the battery is being maintained fully charged and under the above worst-case conditions, the expected battery watering interval shall be_____months.

Turbine Starting:

The nominal_____VCD battery shall be designed for turbine starting service and shall be
capable of delivering_____amperes inrush current to an end voltage of
_____VDC for
_____ seconds. Following "turbine light-off", the battery shall additionally provide
_____   amperes current to an end voltage of_VDC for_____seconds to accelerate the
_____ [Make] gas turbine_____[Model] to self-sustaining speed.

Assume a worst case low battery temperature of_____°F and_____complete starting cycles as described with_seconds rest between cycles.

Assume a worst-case high battery operating temperature of_____°F.

Assuming an average battery ambient temperature of_____°F and a maximum of
_____ crank cycles per month, the battery system quoted will have a warranted useful life
(will handle the load profile described) of_____years "Full Replacement Guarantee,"
followed by_____years "Prorated Warranty" while operating on an adequately sized
charger to maintain the battery.

The minimum charger size recommended by the battery manufacturer is_____amps. The recommended "Equalize" voltage is _____V/C = _____VDC.

The Recommended "Float" voltage is
_____V/

C = _____VDC.

The Recommended "Equalize" voltage is
_____V/

C = _____VDC.

While the battery is being maintained fully charged under the above worst-case conditions, the battery watering interval shall be____months.

GENERAL SPECIFICATIONS

The nominal_____VDC battery shall be designed for communications, switchgear,
industrial, etc. service and shall be capable of delivering_____amperes for
_____seconds
followed by_____ amperes for _____ VDC measured at the battery terminals.

Assume a worst-case low battery operating temperature of_____°F. Assume a worst-case high battery operating temperature of_____°F.

Assuming an average battery ambient temperature of_____°F, and a maximum of
_____ Power outages per month, the battery system quoted will have a warranted useful life (will handle the load profile described) of___years "Full Replacement Guarantee,"
followed by_____years "Prorated Warranty" while operating on an adequately sized
charger to maintain the battery.
The minimum charger size recommended by the battery
        manufacturer is
_____Amps + all additional continuous DC Loads. The recommended

"Float" voltage is_____V/C, = _____VDC. The recommended "Recharge" voltage is____V/C, = _____VDC.

While the battery is being maintained fully charged under the above worst-case conditions, the expected battery watering interval shall be_____months.

Notes to Specifications:

Note 1: In place of a word description of the load profile, a graphic description may be desired, e.g.

Note 2: To get optimum life from any of the various battery types available, they must be kept fully charged without overcharging. The desired charging voltages of the various battery types (or similar types with different specific gravity electrolyte) are, of course, different. However, they can each be charged by the same battery charger by simply setting its "Float" and "Recharge" voltage to the desired setting:

Typical Float and Recharge Settings

Typical Float and Recharge Settings

	Float V/C	Recharge V/C
Flooded SLI@ 1.265 sp.g	2.25	2.35
Flooded Lead Acid Stationary	2.2	2.33
Flooded Nickel Cadmium	1.42	1.6
Maintenance Free Lead Acid	2.3	2.4
Recombinant Nickle Cadmium	1.39	1.45

Some charger designs do not allow any field adjustment because of concern that the voltages will be tampered with. This is a valid concern, but perhaps a more supportive solution would be to put locks on the float and recharge voltage adjustment controls. At any rate, whether field adjustable or not, care must be taken to assure the voltages will not be changed due to vibration or unauthorized tampering. This is, of course, a different concern than the charger output regulation which is discussed in Section 15.

Note 3: Switchgear Applications - For switchgear applications, 60 Hz AC switchgear will activate in approximately 4-6 cycles of input power. Therefore, specifying one (1.0) second (for nickel cadmium batteries) for this function provides a safety margin of at least ten times. (For lead acid batteries use one minute as the minimum time period for any load).

Note 4: Battery Racks – The battery racks should be painted with alkaline-resistant paint (for nickel cadmium batteries) or acid-resistant paint (for lead acid batteries). If earthquake or other shock specification requirements are specified in the invitation to bid, the Uniform Building Code Seismic Risk Zone should be specified. (See Section 23.)

Note 5: Battery Cabling – The electrical connection between the battery and the load shall be configured to hold the cable resistance to a minimum. A reasonable total (positive to negative) conductor resistance for heavy load drains, i.e., engine cranking is:

.0015 Ohms for 12 V systems
.002 Ohms for 24 V systems
.0025 Ohms for 32 V systems

BATTERY SIZING

It is our intention to provide an aid to <u>rapid</u> and <u>effective</u> selection of the proper cell type based on technical and economic considerations. The two most often used battery sizing methods are "IEEE 485" (for lead acid batteries) and "IEEE 1115" (for NiCad batteries) and the "Subtractive Method" for all battery types.

The IEEE method (copies can be obtained directly from IEEE, 345 East 47th Street, New York, NY 10017) is the most precise. However, for engineers who are not sizing batteries on a daily basis, it gives no estimate to compare the final calculations against.

The beauty of the subtractive method is twofold. First, within a minute or two of defining the load profile, you can determine a maximum (above which) and a minimum (below which) you have made a simple math error. The second advantage of this method is its simplicity. It has taken a few compromises as compared to the IEEE methods, but all these compromises work to pick a slightly larger battery, therefore, a safety margin for the System.

Because none of the battery manufacturers have an infinite number of cell sizes, you are usually calculating and ideal cell size and then actually using the next higher of what is available. (The next lower would be too small.) If you were to calculate a group of different load profiles with both sizing methods and then select a battery type from any manufacturer, it would be rare that you would wind up with a different cell size for any of the load profiles. However, as mentioned, if any of the cell sizes were larger, it would be from the subtractive method.

BEGINNING CALCULATIONS

Step I

For either sizing method used, the first step is to choose a desired cell type from a specific manufacturer. In order to make a wise choice, we must consider various conditions of the application.

Types of Loads:

Continuous Loads (Present and
Planned) (Normally carried by
charger)

Typical continuous loads are:
1. Lighting
2. Continuously operating motors
3. Inverters
4. Indicating Lights
5. Continuously energized coils
6. Annunciator loads

Non-continuous Loads
(May come on at any time and last any duration)

Notes: 1. If no specific start or end time can be established, it must be considered
continuous.
2. If a start time can be established but the shutdown time is indefinite, it
must be assumed to continue through the remainder of the duty cycle.

Typical non-continuous loads are:

1. Emergency pump motors
2. Critical ventilation system motors
3. Communication system power supplies
4. Fire protection system

Momentary Loads*
*Assume one minute minimum for lead acid batteries; one second minimum for nickel
cadmium batteries.

If a sequence cannot be established, use the sum of all momentary loads during that
period.

If a sequence can be established, use the maximum DC current at any instant.

Typical momentary loads are:

1. Switchgear operations
2. Motor-driven valve operations
3. Isolating switch operations.
4. Field flashing of generators
5. Motor starting currents
6. Inrush currents

Random Loads
(Can occur at any time of the duty cycle)

Therefore, assume random loads operate at the worst-case part of the duty cycle.

Size the battery without the random load, then add the random load to the worst case (controlling) portion of the load profile.

General Note: Almost all loads are not constant current.

- A small percent is constant impedance (as the DC voltage drops, the DC amps drop)

Most are constant power (as the DCV drops, the DCA's increase)

CELL TYPE

To aid in determining the desired cell type, consider the following:

- Lead acid / nickel cadmium
- Flooded / VRLA/Recombinant type
- Planned life of the installation
- Frequency and depth of discharge
- Ambient temperature
- Seismic requirements

ELECTRICAL CONTRAINTS

Maximum System
Voltage Voltage
Window

Minimum System Voltage

PHYSICAL CONTRAINTS

Temperature Correction Factor

<u>Lead Acid Cell Size Correction Factors for Temperatures</u>

Electrolyte Temperatures		Cell Size Correction Factor	Electrolyte Temperature		Cell Size Correction Factor
°F	°C		°F	°C	
25	-3.9	1.52	80	26.7	0.98
30	-1.1	1.43	85	29.4	0.96
35	1.7	1.35	90	32.2	0.94
40	4.4	1.30	95	35.0	0.93
45	7.2	1.25	100	37.8	0.91
50	10.0	1.19	105	40.6	0.89
55	12.8	1.15	110	43.3	0.88
60	15.6	1.11	115	46.1	0.87
65	18.3	1.08	120	48.9	0.86
70	21.1	1.04	125	51.7	0.85
77	25.0	1.00			

Design Margin:

- Unforeseen additions to the system load
- Lower ambient temperatures than anticipated
- Recent discharge

Usually 10-15% more than calculated value e.g.

100 AH
Battery
<u>x(1.15)</u>
= 115 AH Battery

First, to properly size any battery, the duty cycle must be defined:

- How many amperes
- For how long
- To what end voltage
- At what temperature

The size of the battery required depends not only on the size of and duration of each load, but also on the <u>sequence</u> in which the loads occur.

The number of cells in the battery for any specific system is a matter of adapting to suit the voltage available for charging and the voltage required at the end of the discharge period (voltage window). The most frequently used systems you will encounter and the number of cells normally applied are given on the following table:

Note: It is not uncommon to vary the number of cells for a specific application.

Nominal battery voltage	120	48	32	24	12
No. of lead acid cells	60	24	16	12	6
No. of nickel cadmium cells	92	37	25	19-20	10
Recharge voltage	147	59	40	32	16
Float voltage	129	51	34	26	13
End voltage *	105	42	27	21	10.5
Voltage window	147-105	59-42	40-28	32-21	16-10.5

* The end voltage is a limit imposed by the manufacturer of the electrical equipment being powered. However, as a general rule of thumb, lead acid cells should not be discharged below 75% of their nominal voltage (1.5 v/c), and nickel cadmium cells should not be discharged below 50% of their nominal voltage (0.6 v/c).

ACTUAL LOADS FOR SAMPLE SIZING CALCUATIONS

PROJECT PARAMETERS

24 VDC System
Maximum Voltage: 30 VDC
Minimum Voltage: 21 VDC

60°F Ambient (worst-case)
20 Year design life
24 Hour recharge
10% Future growth (design margin)

Charger Input Voltage: 120VDC,1Ø, 60 Hz

LOAD PROFILE

L1 = 300 ADC
T1 = 1 Sec. (NOTE 1: For Lead Acid Batteries do not use published Data less than the 1 minute, or the load may fail before the electrons begin to move through the plates.)

L2 = 20 ADC
T2 = 3 Hrs.

L3 = 90 ADC
T3 = 2 Hrs.

L4 = 120 ADC
T4 = 1 Min.

NOTE 2; Size the Battery, then add the "Random Loads" in at the time when the "Needed AH Capacity" is the greatest.

NOTE 3: Many times, when you have a series of repetitive loads of the same magnitude, as with Switchgear Tripping or Lube Oil Pumps on a Turbine the easiest way to deal with them is to calculate the "AH Required" and the "AH Removed" for a specific event, then multiply these two numbers by their number of events minus 1, and add this to the total needed, then confirm you have enough AH's Remaining to handle the last Repetitive Load in the sequence.

NOTE 4: Different cell types, even from the same manufacturer, will vary greatly in their ability to meet a specific load profile even though they may provide the same AH capacity at the 8-hour rate.

Step II

Next, ascertain from the Data Sheet the current available for each time period of the load profile T1 through T(final) to the end voltage specified. For calculation purposes, the following "available currents" are used:

For this example, we are using data from the Yuasa Exide EC Data Sheet:

Average Cell Performance Data*
Discharge Rates in Amperes**

TYPE	NOM. Ah CAP.[1]	72 HR	24 HR	12 HR	8 HR	5 HR	4 HR	3 HR	2 HR	1.5 HR	1 HR	30 MIN	15 MIN	1 MIN	1MIN[2] TO 1.50 VPC
						TO 1.75 END VOLTS PER CELL									
EC-5	180	9	16	18	22	33	39	49	66	80	103	146	190	272	570
EC-7	265	13	24	28	33	49	59	73	98	120	154	220	285	408	870
EC-9	350	17	31	37	44	65	78	97	131	160	205	293	380	544	1120
EC-11	440	21	39	46	55	82	98	122	164	199	257	366	475	680	1350
EC-13	535	26	47	55	67	98	117	146	197	239	308	439	570	816	1560
EC-15	620	30	55	64	78	114	137	170	229	279	359	512	665	952	1820
EC-17	710	34	63	73	89	131	156	195	262	319	411	577	744	1040	2000
EC-19	800	38	71	83	100	147	176	219	295	359	462	640	819	1130	2170
EC-21	890	43	78	92	111	163	195	244	328	399	513	702	890	1210	2320

T1	1 Min.	408 ADC
T2	3 Hr.	20 ADC
T3	2 Hr.	90 ADC
T4	1 Min.	120 ADC

Step III

Calculate the AH capacity required for each time period and the AH capacity removed for each time period.

CALCULATIONS (Subtractive Method)

	AH Required	AH Removed
T1 (1 Min.)	300 A/408A (285 AH= <u>210</u> AH	300 A (1 Min./60Min./Hr.) = <u>5</u> AH
T2 (3 Hr.)	20 A/49A (180 AH) = <u>74</u> AH	20 A (3 Hr.) = <u>60</u> AH

T3 (2 Hr.)   90A/98A (285 AH) = <u>262</u> **AH**   90 A (2 Hr.) = <u>180</u> **AH**

T4 (1 Min.)   120 A/272A (180 AH) = <u>80</u> **AH**   120 A (1 Min./60 Min./Hr.) = <u>2</u> **AH**

<div align="center">

Maximum = 626 AH   **Minimum = 247 AH**

</div>

You have now determined the maximum and minimum cell size for final comparison. The maximum is the sum of all capacities for each step of the load profile. The minimum is the area under the curve. NOTE: If the total load profile is considerably longer than 8 hours, it is possible the AH capacity of the final battery selected may be smaller than this (minimum) because battery capacities increase above their 8-hour rate when discharged at a lower current over a longer period of time.

Step IV

From Step III, we can see the most critical part of the load profile is T3 when a 262 AH cell is required. Therefore, the worst-case time for any random load to be applied would be during the last part of T3.

Step V

Final calculations are the same as those of Step III except any random load is inserted at T3.

Check the needed AH Capacity:

If you start with the EC-11 Cell with 265 AH and remove 5 AH's. during T1 you are left with 260 AH's for T2 which only needs 74 AH but only Removes 60AHr's. then you have + 200 AH's. left for T3. However, T3 needs 262 AH's. therefore, you really needed to start with (62 AH's + 265 AH's = 327 AH.

Starting over:
327 AH at T1 -5AH during T1 = 322 AH left for T2. T2 only needs 74 AH, and only removes 60 AH, therefore you have 322-60 = 262 AH left for T3. This would be exactly what T3 needs. T3 only removes 180 AH, leaving you with 262 AH – 180 AH = 82 AH. You only remove 80 AH's. for T4, so everything would be good except they don't have a 327 AH Cell anyway.

HOWEVER: We must now take into consideration the original specific "Load Profiles Specified on page 10 above".

PROJECT PARAMETERS

24 VDC System
Maximum Voltage:
30 VDC Minimum
Voltage: 21 VDC

60°F Ambient (worst case) FROM PAGE = 0.87 (Therefore multiply by 1/.87 = 1.15) 20 Year design life (Therefore multiply by 1.25)
24 Hour recharge

10% Future growth (design margin) (Therefore multiply by 1.10)

With these considerations you really need 327 AH (1.15) (1.25) (1.10) = 527 AH. The EC 13 is a 535 AH Cell. This is what you would really need.
General Information, (Step VI)

If any portion of the load profile, the AH capacity remaining in the battery would have been less than the AH capacity required for that portion of the load profile, the difference would have had to be added to the AH calculated.

IEEE specifications state that a battery will provide 80% of its original rated capacity at the end of its design life; therefore, in order to provide full capacity at the end of the design life, the calculated size must be divided by 0.8.

For future growth, the calculated battery size should be increased by the desired future growth factor.

For reduced temperature applications, the calculated battery size should be divided by the cell size correction factor given in page 9 above.

Two factors in Battery Sizing that are both true but are in direct conflict with each other.

1. If you started with a new, fully charged 100 AH cell and removed 40 AH of capacity, the cell would only be 60% charged. Because the specific gravity of the electrolyte in a lead acid cell drops as the cell is discharged, and because as the specific gravity drops the internal impedance of the cell increases, it could be assumed that a fully charged 60 AH cell would provide more rapid discharge capacity than a 100 AH cell that had been 40% discharged.

2. The rapid discharge capacity of a cell is primarily a function of the total plate surface area in the cell and, of course, the place surface area in the cell does not change with charge. Therefore, it could be assumed that a 100 AH cell that was only 60% charged would have more rapid discharge capacity than a fully charged 60 AH cell.

As is seen, these two assumptions are both based on truth and sound logic when taken separately but are in direct conflict. The truth, as might be expected, is not this simple because many other variables are also involved.
As a rule of thumb, for discharge periods under 5 minutes and for cells discharged less than 40%, it is just about a standoff and both considerations can be ignored.

For discharge periods longer than 5 minutes, the value gained by plate surface area is less important, and therefore, a lead acid battery cell size would need to be increased for the loss of specific gravity.

For cells discharged more than 40%, the cell size would also need to be increased to compensate for this higher internal impedance.

For nickel cadmium cells, because the specific gravity of the electrolyte is constant regardless of the state of charge, you benefit from the larger plate surface area without any losses because of electrolyte change, however it is not enough to write home about.

LEAD ACID TYPE STATIONARY BATTERY

SPECIFICATION

No. SEI-BATT-060190

CONTENTS

LEAD-ACID TYPE STATIONARY BATTERY

1.0 Scope

1.1 This specification covers the requirements for single or multi-cell lead acid stationary battery complete with battery rack, intercell and intertier connectors, terminal lugs and maintenance accessories. Battery types covered by this specification include wet flooded and maintenance free.

1.2 The requirements (load profile, voltage, discharge rate, service conditions, applications data, etc.) for the specific battery shall be as listed on the attached battery sheet.

1.3 Quotations will be considered to meet exactly all requirements of this specification unless specific exception is made on a paragraph-by-paragraph basis.

2.0 General Requirement

2.1 The material and equipment shall, unless amended herein, be designed, manufactured, inspected and tested in accordance with the latest revision of pertinent ANSI, IEEE and NEMA standards, including the following:

2.2.1 IEEE Std. 485 – Large Lead   IEEE Recommended Practice for Sizing

Storage Batteries for Generating Stations and Substations.

2.2.2 NEMA Pub IB 1 - Acid   Definitions and Precautionary Labels for Lead

Industrial Storage Batteries.

2.2.3 NEMA Pub IB 5 -   Life Testing of Lead-Acid Industrial

Storage

Batteries for Stationary Service.

2.2 Seller shall size battery AH rating and short time discharge rates per IEEE Std. 485 (nominal 8-hour capacity). The capacity shall be based on the load profile, nominal voltage and final discharge voltage as listed on the attached Data Sheet. A 1.1 (10%) growth factor shall be applied to the battery sizing to allow for future growth, if specified on the attached Data Sheet.

    2.2.1 A 1.25 (25%) aging factor shall be applied to the calculated capacity (AH rating) of lead calcium and lead selenium type batteries, if specified on attached Data Sheet.

    2.2.2 In addition, temperature correction factors per IEEE Std. 485 shall be applied to the capacity of all battery types based on the temperatures listed on the attached Data Sheet, if specified on the Data Sheet.

2.3 The battery shall have a life expectancy and prorated warranty of 20 years.

2.4 The battery shall be designed for floating service under normal operation with a periodic equalize charge from a connected battery charger. The seller shall state the safe float and equalize charging voltage ranges on the attached Data Sheet. Battery charger will be furnished under a separate specification.

2.5 Individual cells of the battery shall be shipped filled with the electrolyte and fully charged (wet charged), ready for use.

3.0 Battery Construction

3.1 Battery type and make-up (single or multi-cell) shall be as listed on the attached data sheet.

3.2 Positive Plate Design

    3.2.1 Lead calcium plates shall be of the pasted plate construction with grids cast from lead calcium alloy.

3.3   Negative plates shall be of the pasted plate type construction with rigid lead alloy grids.

3.4   The plates shall be braced and suspended from the container walls or from the cover so as to minimize local vibration and cracking.

3.5   Between each positive and negative plate, there shall be a microporous separator used to improve electrolyte utilization and insulating qualities while maintaining low internal resistance.

3.6   Cell terminal posts shall be heavy duty, manufactured using lead alloy or lead alloy reinforced with copper core inserts and shall have adequate current carrying capacity for the duty cycle. Cell terminal posts shall be equipped with connector bolts having acid-resistant nuts.

   3.6.1   Cell posts shall be sealed against electrolyte creepage using O-rings and lead alloy seal nuts or buyer approved equal.

3.7   The cell containers and covers shall be molded of a high quality translucent or transparent plastic which is resistant to heat, shock and chemical attack. The cell cover shall be permanently sealed to the container to form a leak-proof seal. Covers shall be equipped with explosion resistant, flame arresting vent caps.

3.8   The electrolyte shall be high grade sulfuric acid with the specific gravity for each type of cell listed below. Electrolyte level shall be at least 1.5 inches above the plates. Sufficient space for sediment shall be provided at the bottom of each cell. Electrolyte level lines shall be marked on the front and back of each cell.

3.9   Seller shall provide all inter-cell and inter-tier (if required) connectors and associated hardware. Inter-cell connectors shall be lead plated copper and sized to allow at least ½ inch space between adjacent cells.

3.10   Seller shall furnish quotation for a completely sealed, maintenance free type battery containing plates per Paragraph 3.2.2 and 3.2.3 when specified on the attached Data Sheet. All other requirements of this specification shall also apply except for that of Paragraph 3.8.

4.0   Battery Rack

4.1 Seller shall furnish the number and type of battery racks as listed on the attached Data Sheet.

4.2 Battery racks shall consist of rails, frames and braces made of steel coated with 2 coats of corrosion resistant material with seismic rating as specified on attached Data Sheet.

4.3 The length and depth of the battery rack shall be determined by the seller and listed on the attached Data Sheet under "Seller's Information Provided with Quote."

5.0 Accessories

5.1 Seller shall supply the following accessories:

Thermometer (On wet flooded batteries only) Portable hydrometer (On wet flooded batteries only)
No-oxide compound for intercell and intertier connectors Lifting straps
Adhesive backed cell numbers and warning labels for each cell and rack

LEAD ACID STATIONARY BATTERY DATA SHEET
Part A – Buyer Furnished Data

1.0 Item No._____

2.0 Service Conditions:

Indoor   _____

Outdoor in enclosure _____

Air Conditioned _____

Non-Air Conditioned _____

3.0 Temperature Conditions:

Maximum _____Deg. F

Minimum _____Deg. F

Average   _____Deg. F

4.0 Battery Type:

Plante   _____

Flooded Lead Calcium _____

Flooded Lead Selenium _____

Maint. Fr. Lead Calcium _____

Maint Fr. Lead Selenium _____

5.0 Cell(s):

Single Cell _____

Multi Cell   _____

Final Discharge Voltage:

_____volts per cell

(1.75 v/c usual minimum)

7.0 Nominal D.C. Voltage

24 Volt   _____

48 Volt   _____

125 Volt _____

250 Volt _____

Other   _____

8.0 Battery Rack Type: No. Req. _____

One Tier   _____

Two Tier   _____

Three Tier _____

Two Step   _____

9.0 Battery Rack Construction

FRP   _____

Coated Steel _____

Other   _____

10.0 Battery Seismic Rated

No _

Yes _____

Final Discharge Voltage:

11.0 Qualifications Test Required:

No _

Yes _____

12.0 Factory Discharge Test Required:

No _

Yes _____

13.0 Load Profile (Duty Cycle) – Periods:

		Minutes	Amperes
First Period	-	_____	_____
Second Period	-	_____	_____
Third Period	-	_____	_____
Fourth Period	-	_____	_____
Fifth Period	-	_____	_____
Sixth Period	-	_____	_____
Seventh Period	-	_____	_____
Eighth Period	-	_____	_____

14.0 Other Requirements:

_____

_____

_____

_____

ITEM NO. _____ INQUIRY/P.O. _____

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