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 being given to the battery and 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 failed to provide its expected life because the conditions which cause premature battery failure were not recognized and addressed in the procurement phase.

Batteries are available today which have a guaranteed life of from 90 days to 25 years. With this wide of a product quality range, it is natural the price range is also very wide.

A brief description of the various battery types will follow for the purpose of providing an understanding of the problems and strengths relating to that particular type of battery. There are three basic battery types being used today in industrial float service applications:

Flooded Vented Lead Acid
Flooded Vented Nickel Cadmium
Maintenance Free Lead Acid.

The guaranteed life of each type ranges from 1-20 years, 1-25 years and 1-20 years, respectively.

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 a 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 (usually 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; and when they are not being charged, they were expected to be sitting open circuit.

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 which can be specified on the charger to greatly improve the life of SLI batteries in float service. However, even with the best chargers, they will probably have shorter lives than an identical SLI battery in your own family car.

The flood vented lead acid stationary battery will last much longer than its SLI counterpart. Because it is usually 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 battery is probably the longest life battery used in industrial applications. It also is, perhaps, the most forgiving of all batteries in response to overcharge, undercharge, temperature extremes, vibrations, etc. It is also far above all the other types except for the 20 year maintenance free lead acid type in initial capital equipment cost. For years the nickel cadmium battery was also considered a lower maintenance battery. But nothing is lower than nothing, and the better maintenance free batteries available today will really provide virtually maintenance free operation for up to 15-20 years. Typically, the only maintenance required would be re-torquing the terminal connections every 2-3 years and keeping the battery clean.

The maintenance free lead acid battery is a float service stationary battery originally designed for short, fast discharges (10-15 minute UPS applications and under one minute switch gear applications). Some manufacturers have expanded part of their maintenance free 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 maintenance free battery meets high shock and vibration specs and some of the smaller ones are virtually non-position sensitive.

As a supplier of all of 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 there are other brands.

It may not be your desire to write a battery specification around one 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 blanks open and let each potential supplier provide you this information on his or her equipment to assist you in evaluating the 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 ______ [number] each ______ second cranking periods with ______ seconds rest between cranks.

Assume a worst case low engine cranking temperature of ______°F [usually between 40 and 120°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. The recommended "recharge" voltage is ______ v/c.

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 ______ VDC 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 three 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 "float" voltage is ______ v/c. The recommended "recharge" voltage is ______ v/c.

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 <u>communications, switchgear, industrial, etc.</u> service and shall be capable of delivering ______ amperes for ______ seconds followed by ______ amperes for ______ seconds to not less than ______ 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.

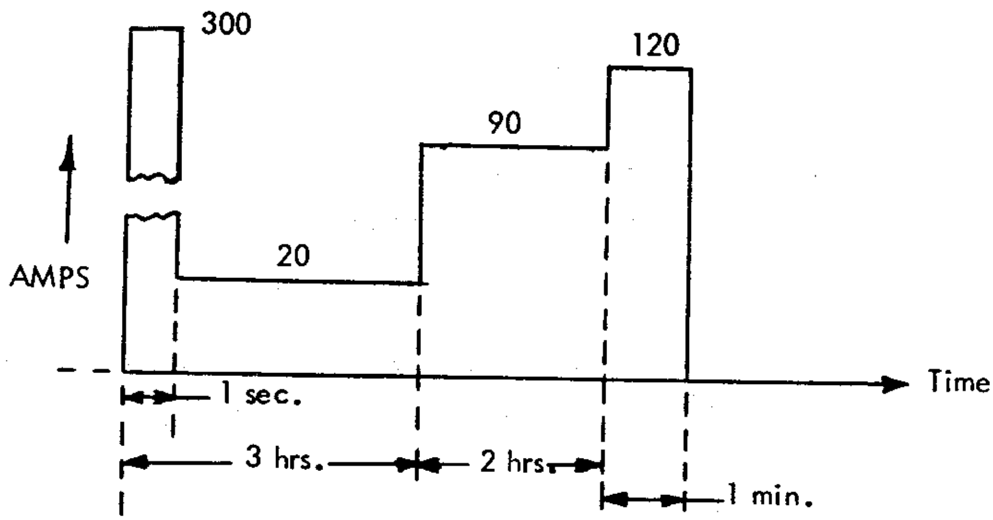
Assuming an average battery ambient temperature of ______ °F and a maximum of ______ cycles per month, the battery system quoted will have a warranted useful life (will handle the load profile described) of ______ years "Full Replacement Guarantee", followed by ______ years "Prorated Warranty" while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

The minimum charger size recommended by the battery manufacturer is ______ amps. The recommended "float" voltage is ______ v/c. The recommended "recharge" voltage is ______ v/c.

While the battery is being maintained fully charged under the above worst case conditions, the 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

	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

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: For switchgear applications, 60 Hz AC switchgear will activate in approximately 4 to 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 and 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 rapid and effective 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 "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 calculation 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 485 method, but all of these compromises work to pick a slightly larger battery, therefore, a safety margin.

Because none of the battery manufacturers have an infinite number of cell sizes, you are usually calculating an 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 for 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 systems

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 are 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 / maintenance free
- Planned life of the installation
- Frequency and depth of discharge
- Ambient temperature
- Seismic requirements

ELECTRICAL CONSTRAINTS

Maximum System Voltage

Voltage Window

Minimum System Voltage

PHYSICAL CONSTRAINTS

Temperature Correction Factor

Lead Acid Cell Size Correction Factors for Temperature

Electrolyte Temperature (°F)	Electrolyte Temperature (°C)	Cell Size Correction Factor	Electrolyte Temperature (°F)	Electrolyte Temperature (°C)	Cell Size Correction Factor
25	-3.9	1.52	80	26.7	.98
30	-1.1	1.43	85	29.4	.96
35	1.7	1.35	90	32.2	.94
40	4.4	1.30	95	35.0	.93
45	7.2	1.25	100	37.8	.91
50	10.0	1.19	105	40.6	.89
55	12.8	1.15	110	43.3	.88
60	15.6	1.11	115	46.1	.87
65	18.3	1.08	120	48.9	.86
70	21.1	1.04	125	51.7	.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
x (1.15)
= 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 battery required depends not only on the size and duration of each load, but also on the sequence 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 CALCULATIONS

Continuous:	25A for 8 Hr. 4A 8hrs
Momentary:	200A for First Min. 36A
	75A for Last Min.
Non-Continuous:	75A from 1 Min. - 2 Hr.
	100A from 1/2 Hr. - 3 Hr.
Random:	75A for 1 Min.

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: 120 VDC, 1Ø, 60 Hz

Load Profile

L1 = 225A
T1 = 1 Min.

L2 = 100A
T2 = 29 Min.

L3 = 200A
T3 = 1.5 Hr.

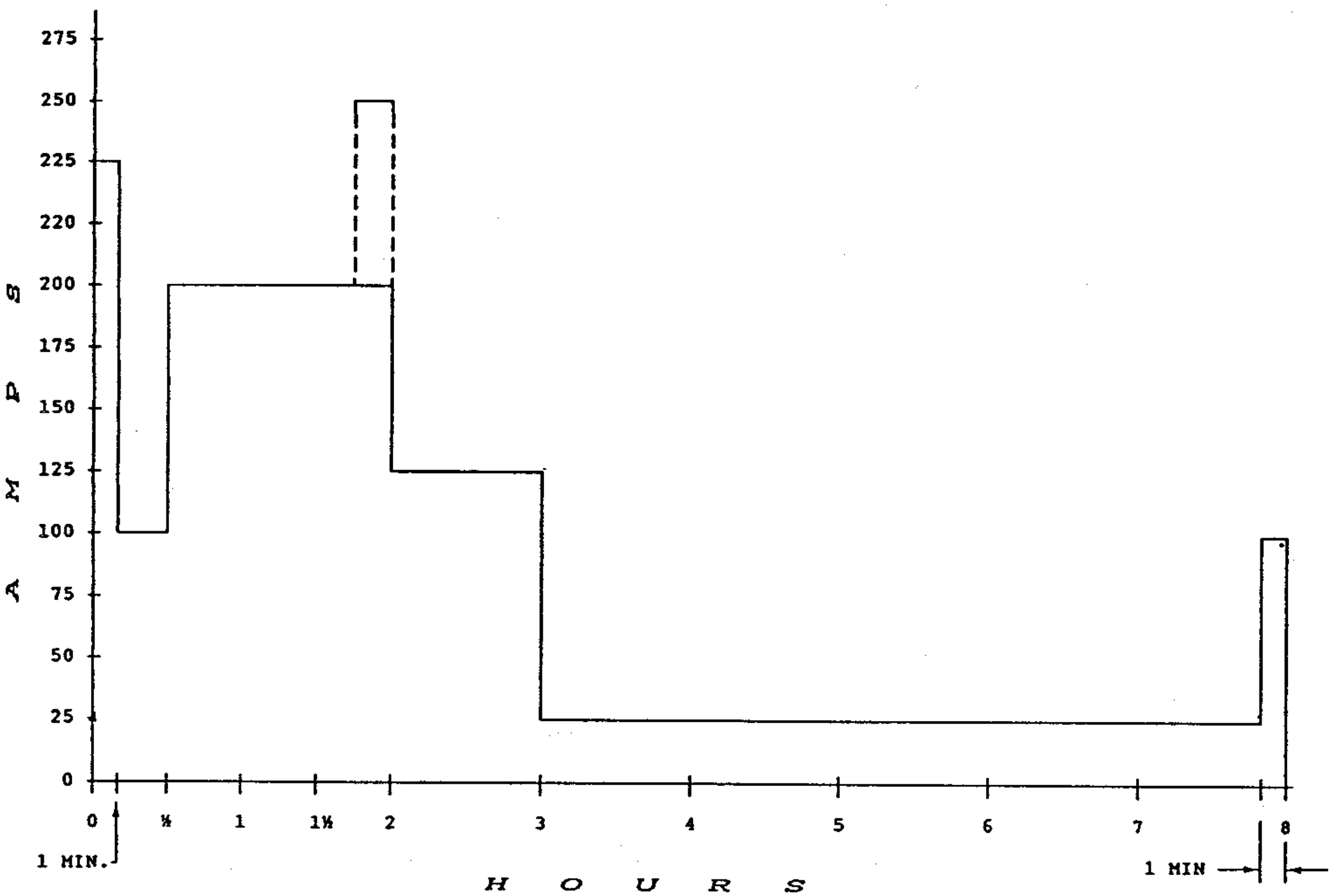
L4 = 125A
T4 = 1 Hr.

L5 = 25A
T5 = 5 Hr.

L6 = 100A
T6 = 1 Min.

L (Random) = 75A
T (R) = 1 Min.

Load Profile (Pictoral)



NOTE: 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:

Load Sequence	Available Current
T1 = 1 Min.	I = 978 ADC
T2 = 1/2 Hr.	I = 576 ADC
T3 = 1.5 Hr.	I = 342 ADC
T4 = 1 Hr.	I = 432 ADC
T5 = 5 Hr.	I = 156 ADC
T6 = 1 Min.	I = 978 ADC
T Random = 1 Min.	I = 978 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.)	225A/978A (825AH) = 190AH	225A (1 Min.)/(60 Min./Hr) = 4AH
T2(29 Min.) Use 30 Min.	100A/576A (825AH) = 144AH	100A (29 Min.)/(60 Min./Hr) = 49AH
T3(1.5 Hr)	200A/342A (825AH) = 483AH	200A (1.5 Hr.) = 300AH
T4(1 Hr)	125A/432A (825AH) = 239AH	125A (1 Hr.) = 125AH
T5(4H,59M) Use 5 Hr.	25A/156A (825AH) = 133AH	25A (5 Hr.) = 125AH
T6(1 Min.)	100A/978A (825AH) = 85AH	100A (1 Min.)/(60 Min./Hr) = 2AH
T random	75A/978A (825AH) = 64AH	75A (1 Min.)/(60 Min./Hr) = 2AH
	Maximum = 1338AH	Minimum = 607AH

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 time period.

Step IV

From Step III, we can see the most critical part of the load profile is T3 when a 483 AH cell is required. Therefore, the worst case time for the random load to be applied would be during the last minute of T3.

New $T3^1$ (Result of Random Load)

This load will be applied the last minute of T3.

$L3^1$ = 200A from T3 + 75A from T Random

$T3^1$(1 Min.) 275A/978A (825AH) = 231AH 275A (1 Min.)/(60 Min./Hr) = 5AH

Step V

Final calculations are the same as those of Step III except the random load is inserted at $T3^1$.

CALCULATIONS (Final)

AH Required		AH Removed	
T1(1 Min.)	225A/978A (825AH) = 190AH	225A (1 Min.)/(60 Min./Hr)	= 4AH
T2(29 Min.) Use 30 Min.	100A/576A (825AH) = 144AH	100A (29 Min.)/(60 Min./Hr)	= 49AH
T3(1.5 Hr)	200A/342A (825AH) = 483AH	200A (1.5 Hr.)	= 300AH

T3[1] (1 Min.)	275A/978A (825AH) = 231AH	275A (1 Min.)/(60 Min./Hr)	= 5AH
T4(1 Hr)	125A/432A (825AH) = 239AH	125A (1 Hr.)	= 125AH
T5(4H,59M) Use 5 Hr.	25A/156A (825AH) = 133AH	25A (5 Hr.)	= 125AH
T6(1 Min.)	100A/978A (825AH) = 85AH	100A (1 Min.)/(60 Min./Hr)	= 2AH

Therefore, the minimum actual cell size needed is the 85 AH required for T6 plus all AH's previously removed.

		(T6)		(T5)		(T4)		(T3[1])		(T3)		(T2)		(T1)	
AH	=	85AH	+	125AH	+	125AH	+	5AH	+	300AH	+	49AH	+	4AH	= 693AH

<u>Step VI</u>

Check this size against the load profile:

T1	693AH at start is larger than needed for T1
T2	693AH - 4AH = 689AH is larger than needed for T2
T3	689AH - 49AH = 640AH is larger than needed for T3
T3[1]	640AH - 300AH = 340AH is larger than needed for T3[1]
T4	340AH - 5AH = 335AH is larger than needed for T4
T5	335AH - 125AH = 210AH is larger than needed for T5
T6	210AH - 125AH = 85AH required for T6

NOTE 1: If at 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 693 AH calculated.

NOTE 2: IEEE specifications state 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 .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 Section 20, Page 2.

Step VII

Select battery

693 AH (Actual Minimum Cell Size)

( ) Over size for battery life

( ) Over size for design margin

( ) Over size for temperature (etc.)

_______ AH Required

Note: For the sizing application

693 AH

\+ 174 AH (25% for 20 year design life)

\+ 77 AH (11% for 60°F ambient)

\+ 70 AH (10% for future growth)

1014 AH

Therefore, use a battery of 1014 AH capacity or the next size larger.

Note 1: To better understand how to select the proper cell size, two factors need to be understood:

1. If you started with a new, fully charged 100 AH cell and removed 40 AH of capacity, the cell would be only 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 can 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 plate surface area in the cell does not change with charge. Therefore, it can 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 logical 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 stand off 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, the 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.

Note 2: 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.

LEAD ACID TYPE STATIONARY BATTERY

SPECIFICATION

No. CPSI-BATT-060190-GB

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, application data, etc.) for the specific battery shall be as listed on the attached Data 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 - IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations.

2.2.2 NEMA Pub. IB 1- Definitions and Precautionary Labels for Lead Acid 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 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 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 <u>Battery Construction</u>

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:

3.1.1 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.

3.8.1 Lead calcium cells shall have a fully charged specific gravity of 1.215 at 77°F.

3.9 Seller shall provide all intercell and intertier (if required) connectors and associated hardware. Intercell connectors shall be dual strap, lead plated copper and sized to allow at least 1/2-inch space between adjacent cells.

3.10 Seller shall furnish quotation for a completely sealed, maintenance free type battery containing plates per Paragraphs 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 cells 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:

- Planté ______
- Flooded lead calcium ______
- Flooded lead selenium ______
- Maint. Fr. lead calcium ______
- Maint. Fr. lead selenium ______

5.0 Cell(s):

- Single cell ______
- Multi-cell ______

6.0 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___ Seismic Zone ___

11.0 Qualification Test Required:

No___ Yes___

12.0 Factory Discharge Test Req'd:

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. ____________________