LEAD ACID BATTERY SPECIFICATION WRITING – KEEP IT RELEVANT AND SIMPLE!

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ABSTRACT

When designing a stationary, lead-acid battery system, crafting the specifications relevant to the application and usage of the project facilitates the selection of the right battery. This in turn will result in satisfactory battery life, less remedial maintenance, capital savings, and most importantly, reliable back-up power. This paper identifies which factors are important, which ones are not, and which design features are relevant to the performance of the battery. This paper will assist the end-user in writing a meaningful specification that will ensure the batteries offered will match the application without sacrificing quality.

INTRODUCTION

Let's start by stating that after reading this article, you still will not know what the best battery is for your application. This can only be done by defining your application, examining your preferences and comparing all of the potential batteries that are appropriate for your application.

The first task is to identify the people who will read and use the specifications. The target audience can be wide ranging from purchasing person to engineer making the selection to salesperson preparing quotes. This means the specification must be direct to the point and should be clear, focused, and concise. This document will tell you how to write a specification that will result in the best and most appropriate battery models being offered to you for purchase. There are style and technical aspects one must consider when writing a specification.

WRITING STYLE

Specifications too often contain wasteful phrases that can be easily misunderstood or simply waste everyone's time. Often used phrase are "except as otherwise specified" or "unless otherwise shown or directed". These should only be used in conjunction with clear directions to locate any such qualifying information. Otherwise these types of phrases lead the reader to wonder if there are hidden meanings or requirements in the specification. Does it mean there is some detail of the battery requirement which is different than all the other details? Does the reader have to sort through all the documents looking for any such exceptions? If the reader doesn't find the exception because there are no such exceptions, everyone's time is wasted with unnecessary questions. The battery specifications must be free of any ambiguous and wasteful phrases.

A specification written in present tense is easier to write, easier to maintain, has longer useful life, and can avoid specification creep. The language tends to become unclear when a specification is written in the future tense and words like *will*, *shall*, and *should* appear on the specification. These words brings into question whether the parameters are mandatory or not. The specification written in the present tense makes the language clear and direct. It also describes the requirement in present mode and prevents specification creep.

TECHNICAL ASPECT

There are three major sections that are necessary to have a meaningful lead-acid battery specification. The first section describes the battery and its usage fully. This is necessary for the supplier to understand what needs to be done and what the expectations are for the power system. The second section summarizes the customer's preferences in terms of the battery type and features. This is important so that the supplier can narrow down the multitude of choices that are possible candidates. The last section defines specific features or criteria that the battery must meet as determined by the customer.

If this process is followed well by the customer, the result will be a successful RFQ. The products offered will match the application, there will be flexibility on the supplier's side to offer new products that offer better performance, and the customer will be able to directly compare the products offered.

Section 1 – Application Definition

First things first. The customer must fully describe the application. This section is often neglected, but is the most critical section to a proper response from the suppliers. It is not sufficient to simply list the model of the existing battery. It is strongly suggested that the specification writer become familiar with the IEEE Standards for Stationery Batteries. These are a series of recommended practices that cover sizing, selection and maintenance for most of the applications in which lead acid batteries are used. Once the application is determined, review of the applicable standards will be of great assistance in determining what information is critical to proper battery selection. The major areas to define are as follows.

<u>Environment</u>

- Temperature – Although battery ratings and design life are based on 77°F, lead-acid batteries are sensitive to temperature. If operated colder than 77°F, the battery may have to be larger, since the capacity is reduced. If operated warmer, the battery life will be reduced.

  In this section, the most important thing to define is whether the temperature is controlled or not. Controlled means the temperature does not swing with the seasonal temperatures. It can be steady cold or steady hot, but does not vary. The specification should indicate the temperature at which the battery should be sized as well as the operating range. The full, seasonal temperature description is critical for the supplier to provide the correct battery, to offer the proper warranty and to provide the proper price.

- Seismic location – The customer should specifically state whether he/she requires that the battery system be seismically qualified and to what code. This can dramatically affect the price and the space (including height) limitation of various battery layouts. It is important to determine that all offerings meet the same requirements.

- Other – There are numerous other descriptions of the environment that may or may not be important, depending on the specific application site. If in doubt, include it in the RFQ. These may include altitude, humidity, exposure to sea atmosphere, exposure to chemical atmosphere, corrosive atmosphere, vibration from nearby equipment, etc. These items may prompt the battery supplier to provide upgraded components or optional protective devices, which may make the difference between a long-lasting, successful installation and a disappointingly short one.

<u>Duty Cycle</u>

This section is equally important to properly match the battery to the application. Many times, customers will simply put in the nameplate of the existing battery and request an equivalent. This is not sufficient. The overall usage profile must be described as either a float battery or a cycle battery. This affects the battery design, the charger design, the expected modes of failure, and expected service life. Note that most traditional, industrial, stationary applications are float applications. This includes the conventional telecom CO, telecom OSP, UPS and utility switchgear applications. Cycle applications include, but are not limited to, photovoltaic, frequency regulation for utilities, off-grid hybrid systems, as well as hybrid and plug-in hybrid automobiles. While lead acid batteries are used in both ‘cycle’ and ‘float’ service, and there may be overlap in some cases, the type of intended service affects the design of the battery. Therefore the type of service should be clearly stated and cycle requirements given in a float application specification should be based on only actual anticipated service to assure selection of appropriate design.

The duty cycle must be described. For cycle service, this can be stated simply as the length and depth of the expected discharge cycles, and the frequency of these cycles. If the depth of discharge can vary, the expected breakdown should be provided. If the power level (amps or watts) of the discharge can vary, this expected breakdown should be provided as well. An example table such as the one below will capture all of this information.

Expected discharge cycles	Number of cycles per year	Percentage at full load	Percentage at 50% load	Percentage at 25% load
To 10% DOD	15	50%	20%	30%
To 50% DOD	9	70%	20%	10%
To 100% DOD	3	90%	10%	0%

For ‘float’ service applications, it is recommended that IEEE-485, Recommended Practice for Sizing Lead Acid Batteries for Stationery Applications, IEEE-1184, Guide for the Selection and Sizing of Batteries for Uninterruptible Power Supplies, and / or IEEE-1189, Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications be reviewed.

<u>Recharge method</u>

If the customer has an existing charger that will be used to recharge the batteries, this must be defined. The information that will be required by the battery supplier is shown below.

- Method of charger – Constant voltage (CV) , constant current (CC) , CVCC, etc. The maximum and minimum settings for voltage and current should be defined, or at least the model number of the charger so that this information can be obtained from the charger manufacturer.
- Minimum time for recharge – This will define the maximum current, which may affect the battery selection
- Charge termination method – If a specific method is used, this should be stated, so the battery can be properly matched. As an example, VRLA batteries with and without catalyst caps will have significantly different top-of-charge current levels, which may affect the charger decision to terminate recharge.
- Equalization – The charger options for equalization should be defined. Different battery chemistries require different equalization levels. This can vary widely per manufacturer’s recommendations from: none required (certain VRLA) to regular (high antimony flooded).

<u>Maintenance issues</u>

The customer should state a minimum amount of information on the expected maintenance levels which will allow the supplier to quote the appropriate product. Information that is important is whether the site is manned or unmanned, whether the site is remote, or can be quickly accessed in an alert. Also, whether the customer has automatic monitoring, or will rely on periodic manned inspections. It is helpful to know if the customer will be following a defined maintenance regiment, such as the IEEE recommended practices, or will use in-house practices.

Since all batteries are not equal, the battery types that are more robust are better matched to a remote, inaccessible, unmonitored site. Other battery types may be higher performing, but require regular and close watch. This information will allow the supplier to offer the battery model best suited to these criteria.

Section 2 – Battery System Preferences

Even with the application properly defined as described above, there will be multiple battery models that can provide the service and perform well. However, most customers have experience with lead-acid battery systems and have predetermined preferences. These are usually driven by various legitimate, though often non-technical reasons, such as customer historical usage, past failures, desire for commonality within customer network, perceived costs, perceived reliability, etc. Regardless of the reason, if the customer has a preference for a certain battery type or configuration, this needs to be defined. If the following preferences are not given by the customer, the supplier typically will offer the least expensive model, which may or may not satisfy the customer’s wants.

<u>Customer preferences</u>

These following variations can all provide battery service properly, and their selection is a matter of customer preference

- VLA (Flooded) vs. VRLA – This is often driven by space limitations, or site issues such as availability of ventilation or spill containment requirements. It can be driven by the appeal of historical reliability and service life, or strictly by initial cost.
- Single vs. Multicell - Single cells are almost always more expensive and require a higher number of unit-to-unit connections, but this method allows individual cells to be replaced or maintained. Also single cells typically provide higher acid-to-active material ratios for better long rate performance. Multicell models are typically less expensive and save space, but are marginally more complex to manufacture and can introduce additional modes of failures, such as seal leaks between adjacent cells.

- Parallel vs. single string – Different industries have different traditions, but there are some general rules of thumb regarding multiple strings. Parallel strings allow maintenance while the system is still available, it can provide for redundancy, and can allow smaller components to be used within each individual string. Overall, however, it is more expensive. Single strings reduce the number of connections, simplify the string balancing issue and reduce maintenance labor.
- Ancillary equipment – Sometimes required by local codes, the inclusion of ancillary equipment should be listed. This includes spill containment, battery monitoring equipment, and other safety equipment.

Section 3 – Specifications and Requirements

The first obvious specifications should center on the dimensional limitations. The space limitations of footprint and height need to be defined. For top terminal batteries, maintenance and top access requires an open area on top of the battery, and so all of the height is not available for the battery dimensions. Also very importantly, the maximum weight of the battery must be defined. Often, battery manufacturers can provide weight distribution plates to mitigate the high loading area at the feet of racks and cabinets.

<u>Battery life</u>

This section can be dealt with in many ways. One way to address this is the following. Rather than the customer requiring that a battery meet a specific lifetime, the life is left as an open line item for the manufacture to fill in. Battery life is defined in three different ways. Based on the application information provide in Section I, the battery supplier estimates the life of the offered battery in each of the following three areas. In this way, the battery manufacture is encouraged to be completely honest and forthright in the life estimates without having to force their products to fit into certain windows. It also gives a supplier a way to differentiate a higher quality battery model that he can then justify with a higher price.

It is thus expected that the customer will receive quotes of batteries of various life estimates, and may receive multiple quotes from a single supplier. The three different battery life estimates that should be requested are the following.

- Design life – This is the estimated life of the battery per the manufacturer's engineering design estimates. All the stipulations need to be listed by the manufacturer. This may have little bearing to the life of the battery in this specific application because of the applicable conditions that are in play.
- Cycle life – The manufacturer should state the number of cycles the battery can provide, under the specified conditions.
- Service life – The manufacturer should provide a best estimate for the life of the battery in the application as defined in this specification.

<u>Materials of construction</u>

The flammability rating of the battery components should be specified. Plastics with a limiting oxygen index (LOI) of greater than 20% will not support combustion in open air. A more restrictive criterion is to require compliance to one of the UL flammability standards, such as UL94 V0, V1 or V2 as required. If this is a requirement, it is important that all items be subjected to this same criteria, such as terminal covers, rack rail covers, cable jackets, and safety equipment.

The durability of the plastic should be specified if desired, as the impact strength. Many plastics are available including polypropylene, polycarbonate, SAN, ABS, PVC and multiple blends of these polymers. The durability can vary widely, from 'robust' to 'fragile'. The highest durability is often desired in high seismic zones and for life-critical applications.

Application Specific Design Features

As a customer, one always wants a battery that is designed specifically for the type of application in question. A general purpose battery often has compromises somewhere in the design that makes it less than ideal for any particular application. This is best revealed by requesting a ratings table. Regardless of the actual duty cycle, the customer should request discharge rates for 15 minute, 1 hour and 8 hour. For switchgear applications, a one minute rate should be included. Comparing these values across all the batteries offered by all the manufacturers will reveal the application for which the battery models have been optimized. High rate designs will obviously excel at the shorter time periods and will perform poorly at long rates, where acid and active material limitation will prove important. Conversely, traditional telecom batteries will perform relatively poorly at the high rates because of the lack of high rate components, such as copper or copper alloy inserted posts and radial grid members. This ratings table will show if a supplier is offering an inappropriately designed battery for this application. The rating table should also show the initial capacity of the battery. It is a good idea to specify that the information supplied for the model include this. It usually ranges between 90 and 100 % capacity. While 90 % initial capacity may be acceptable, it is necessary to know what each model offers for a like to like comparison.

A few specific items are important enough to specify regardless of the ratings table. If the application is a high-rate application (shorter than 1 hour discharges), it is always good to specify copper or copper alloy inserted posts, which have up to 10 times the ability of pure lead to conduct current. This will dramatically improve the current carrying capabilities of the cell, while reducing the temperature rise of the terminals.

Another specific feature to require is 'wrapped plates' for a high cycling flooded battery. A pocket or U-wrapped separator, in addition to a thicker retention mat, is key to obtaining a high cycle count. The wrapped plate design can typically extend the cycle life of a flooded battery by a factor of three.

Warranty

Warranty is very different from the estimate of the battery life discussed in earlier sections. Warranty is a cost issue, not a technical issue, and not a design issue. The importance of specifying a warranty is to obtain the terms and conditions of the warranty.

SUMMARY

The intent of this document is to provide an outline and to educate the reader in how to write a meaningful lead-acid battery specification. The three major sections that should be included in each specification are the following:

1. Definitions of the application – a full description of the environmental conditions, duty cycle, recharge method, and maintenance issues.
2. Customer preferences – While both options will technically satisfy the backup power requirements, these options should be selected by the customer based on their preference. This includes VLA (flooded) vs. VRLA, single cell vs. multicell, and single string vs. parallel.
3. Specified requirements – Final items that should be specified by the customer for a proper application. This includes materials of construction, application specific design features, dimensions and warranty.

If followed, the customer should be rewarded with battery proposals that match the application, that can be directly compared to each other and that allow for a battery manufacturer to offer an improved option for a price premium. This allows the customer to truly evaluate and compare the various offerings to make the best selection and choice possible.