Lead Acid Battery Lifecycle: Terms and Definitions

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Executive summary

There are several terms that describe the anticipated life of a battery. These terms are used by battery manufacturers and users, but are not always well understood by those who use or maintain battery systems. The purpose of this paper is to clarify these terms, and remove any ambiguity regarding their meaning and use. This paper will focus on Valve Regulated Lead Acid (VRLA) batteries, but most of the information provided is also applicable to other lead-acid batteries, and likewise, many other battery chemistries.

Introduction

Battery life can be described by a number of terms, some of which are clearly defined by battery organizations and well understood by those in the battery industry, and some of which are informal terms without clear definitions. As a result, terms intended to describe battery life can confuse or mislead end users who are not completely familiar with battery jargon.

Additionally, several environmental conditions affect battery life and must be considered when the end user is selecting batteries for an application.

To explain what “battery life” terms mean, and why they are used, this paper will describe the terms independently. Following this description, and to explore what battery life terms mean for real world applications, a discussion of a few of the primary environmental variables are provided.

Battery life terms

Design life

Prior to creating a battery, the designer knows all of the basic parameters that the battery must meet. Voltage, ampacity, case size, and design life are all part of the original specification. The designer’s job is to ensure that there is enough active material and electrolyte within the designated case size to provide the voltage and ampacity requirements over the period specified by the design life. The design life is the life expectancy the manufacturer says the battery is capable of, provided that all of the specification parameters are maintained.

The Design Life specification varies from manufacturer to manufacturer, and also from battery model to battery model. The basic Design Life categories for a VRLA battery are 5 year, 10 year, and 12 year. There are several non-standard design life specifications from various manufacturers, but these are not provided by all manufacturers.

The Design Life specification includes all of the environmental variables that typically affect battery life. To follow the specification, it is typical that the following parameters must be met:

- Float voltage accuracy
- Frequency of discharges
- Number of discharges
- Maximum discharge rate
- Depth of discharges
- End voltage limit
- Operating temperature
- The amount of ripple current and voltage allowed, during charging as well as discharging

This is a very strict regimen that has to be followed very accurately in order to achieve the Design Life. Not many installations can maintain that level of control.

Service Life

Unlike Design Life, Service Life has no real specification. What Service Life really designates is approximately how long a battery of a given Design Life will remain reliable, given the real world environment in which it is used. This is generally more of a site-specific life estimate.

When used in uninterruptible power supply (UPS) systems, the environment, both electrically and physically, can be extremely harsh. With modern high efficiency UPS designs, the battery has become much more important as a part of the filtering capability of the UPS. This is because newer designs have eliminated much of the ferroresonance and capacitance that provided the basis for the legacy systems to ride through minor variations in both input power and load fluctuations.

The battery system has, increasingly, been used to meet the capacitance requirement that stabilizes the load on the inverter. This causes numerous micro-discharges, which, coupled with the requirement to meet the demands of more frequent, high-rate discharges caused by utility fluctuations, places the UPS battery on a significantly shortened life cycle trajectory. There are also a number of environmental and electrical factors that affect battery life, and those will be discussed next.

Physical environment concerns

Temperature – The temperature of the area where the batteries are installed is critical. The temperature of the VRLA battery is typically specified at 25°C (77°F) for North America, and 20°C (68°F) for the rest of the world. This specification is for the INTERNAL temperature of the battery, and not for the ambient room temperature. The internal temperature is generally ~1°C (2°F) higher than the ambient room temperature. The temperature difference from top to bottom in a battery room may also be as much as 5°C (10°F). It is important to note that increasing the temperature by 10°C (18°F) will result in roughly a 50% reduction in service battery life. Reducing the temperature by the same amount will also reduce the capacity of the battery by roughly 25%.

Proper commissioning – It is critical to precisely follow the manufacturer's specification for the initial charging of the battery, prior to testing and placing the battery in service. Failure to follow this procedure carefully introduces a high likelihood that the battery will never perform to its potential, and may significantly reduce the service life of the battery.

Stability – The battery needs to be installed in a stable environment. It doesn't perform well in situations where the temperature varies widely, or where one area of the battery is markedly hotter or cooler than the rest of the string. Batteries don't endure vibration well either, therefore a stable foundation is required.

Corrosive environments – The VRLA battery is specifically designed to be installed in occupied spaces, meaning the places where people normally work. Corrosive environments are not places where people normally work, but sometimes batteries are relegated to the most obscure space within a facility. If the battery is not installed in an occupied space, care must be taken to ensure that the environment is not corrosive at the very least.

Electrical environment concerns

Charge voltage – Each individual battery model has a specific charge voltage per cell that it is designed to perform optimally at. This varies from model to model, and from manufacturer to manufacturer. It is critical that the manufacturer's recommendations be followed very closely. With VRLA batteries, there is a very small range of voltage that will allow the battery to properly polarize the positive and negative plates. The battery must operate within this range to achieve the best life expectancy. Some manufacturers allow a significant increase in voltage for rapid recharging following a discharge. DO NOT increase voltage for recharge or "equalization" unless the manufacturer specifically recommends this action for the particular brand and model of battery installed.

Charge current – Each battery brand and model has a specification for the maximum charge current allowed. It is very important to insure that the charging source does not overcharge the battery, as this can cause internal failures.

The opposite end of the charge current spectrum deserves attention, as well. The nominal stable state charge, often referred to as "float charge" is also part of the charging regime. The typical float charge level of a stable state battery is roughly 100 mA per 100 AH of battery capacity. This is not a precise number, and varies with battery design and construction, but it is something that must be watched for significant changes.

The typical UPS battery will not see a truly stable float current due to the rectifier and inverter variations that occur due to changes in input voltage and load factor, but it is recommended that the float current level be observed as an indicator of potential changes within the battery string.

AC ripple voltage and current – While the effects and indications of these two variables are quite different, it is important to note that either one, in excessive amounts, have the potential to damage a battery. It is highly recommended that the manufacturer of the battery be consulted regarding the limits of AC ripple within the string.

Conclusion

What does all of this mean to the end user? What is the big difference between Design Life and Service Life?

If one looks at these terms, and considers them with the simplest explanation, it is easy to see that Design Life is the life expectancy the manufacturer says the battery is capable of, provided that all of the specification parameters are maintained. It is also relatively easy to see that, because of the real-world physical and electrical environmental variables, it is highly unlikely that the Service Life will be anywhere near the Design Life.

Design Life is how long the battery will likely live, given a virtually perfect environment and charge/discharge cycle. The battery is charged to a stable voltage and maintained very accurately by a rectifier that provides very clean DC power. When it is discharged, the discharge is a long duration, low amperage current flow that allows the available active material to be used very efficiently. This type of service is much more likely to be seen in a Central Office environment for a telecommunications provider.

Service Life is how long the battery will probably live, given that it will have to endure all of the variables that are typically very hard to control. The end user can't control how frequently the utility experiences a fluctuation, and the temperature fluctuations are generally larger than the ideal. When a discharge occurs, which happens more frequently than many would believe, the profile is almost the exact opposite of the previous description. The battery is typically sized to provide power for only a brief period of time, but the load demand is very high during the discharge. This discharge profile is a very high amperage discharge for only a few minutes, which does not allow for efficient use of the available active material. The battery is then recharged at a very high current to build the storage capacity up as quickly as possible, so that it can be ready if another outage occurs. Even when the battery is fully recharged, it is very difficult to control how the load profile changes from moment to moment without micromanaging all of the equipment installed. This is beyond the ability of most end users.

Due to the very nature of how most users employ a UPS system, the Service Life provided by most of the batteries is quite good. The UPS battery will experience as many discharges per year, whether in large events or by micro-discharges, as many standby batteries see in their lifetime. Depending on the UPS design, and also on the equipment type that is being fed by the UPS, it is not unusual to see a significant amount of electronic noise and harmonic reflection on the DC bus. All of these are factors that contribute to reduced life.

In today's market, it is quite normal for an end user to specify the very best twelve year Design Life battery, and they see a real Service Life of three to four years. In a perfect world, they would see nine or ten years of service from that battery. Unfortunately, the battery doesn't live in that perfect world.

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