Understanding Sulfation and Recovery in Lead Acid Batteries

Power Designers Sibex
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Introduction

Batteries use a chemical reaction to produce a voltage between their output terminals. The battery has several main components: electrodes, plates, electrolyte, separators, terminals, and housing. The positive plate consists of lead dioxide (PbO_2) and the negative plates consist of lead (Pb), they are immersed in a solution of sulfuric acid (H_2SO_4) and water (H_2O). The reaction of lead and lead oxide with the sulfuric acid electrolyte produces a voltage. Supplying energy to an external load discharges the battery.

During discharge, both plates convert to lead sulfate ($PbSO_4$) and the electrolytes becomes less acidic. This reduces the specific gravity of the solution, which is the chemical "state of charge" of the battery. This causes the voltage to drop in each cell because the voltage is dependent on the differential between the plate materials and the strength of the acid. During discharge, the sulfation of the positive and negative plates appears as soft fine lead-sulfate crystals. As the plates become more sulfated, the sulfate accumulation enlarges and hardens, impeding the process of chemical to electrical conversion, causing premature battery replacement and increasing electricity costs used to re-charge the battery.

Recharging the battery reverses the chemical process; the majority of accumulated sulfate is converted back to sulfuric acid. Desulfation is necessary to remove the residual lead sulfate, restoring capacity and run time.

What is sulfation?

Sulfation occurs each time a battery is discharged and is a normal part of battery operation. The process of sulfation is critical to converting chemical energy into electrical energy, without sulfation there is no electrical energy release from the battery.

Negative plate reaction

$Pb(s) + HSO_4(aq) \rightarrow PbSO_4(s) + H+(aq) + 2e-$

Positive plate reaction

$PbO_2(s) + HSO_4(aq) + 3H+(aq) + 2e- \rightarrow PbSO_4(s) + 2H_2O(l)$

This sulfation reaction is reversible when the battery is charged.

Over time, small sulfate crystal formation is normal and not harmful to the battery. During each charge/discharge cycle, the sulfates will accumulate and build up on the battery plates. The sulfation process is accelerated if the battery is left in a discharged state for a prolonged time; or is not properly and regularly equalized. This leads to the development of large crystals that reduce the battery's active material, decreasing the battery's capacity and performance. Opportunity and Fast, charging, does not fully restore the battery with each charge cycle causing a faster accumulation of lead sulfate; and a more rapid decrease in capacity and run time.

Typically a properly maintained conventionally charged battery will lose 20 minutes of run time each year due to sulfation. An opportunity or fast charged battery, again with good maintenance practices, can lose double that amount.

There are two types of sulfation: soft sulfation, and hard sulfation. If a battery is serviced early, soft sulfation can be corrected by applying a regulated current at a low value with respect to the battery capacity, for an extended period of time.[1]

Pulsating Desulfation Myth

Several companies offer anti-sulfation/Desulfation devices that apply pulses to the battery terminals to prevent and reverse sulfation. Such technologies will lower the sulfation on a healthy battery, but they cannot effectively reverse the condition once present. Pulsing is an unscientific method with a one size fits all approach.[1]

While pulsating anti-sulfation devices may temporarily reverse the condition on an otherwise healthy battery, most battery manufacturers do not recommend pulsing as it tends to create soft shorts, increasing self-discharge. Furthermore, the pulses contain ripple voltage and ripple currents, heating the battery unnecessarily. Battery manufacturers specify the allowable ripple when charging lead acid batteries. Applying random pulses or blindly inducing an overcharge will do more harm to the battery than good, by promoting grid corrosion. [1]

The Power Designers Sibex Approach

All Power Designers Sibex chargers incorporate a proven method of desulfating; applying a regulated current at a low value with respect to the battery capacity, for an extended period of time. The charger incorporates an ability to run a safe, tailored recovery cycle for sulfated batteries, based on nameplate capacity and voltage. This can easily be done through the built-in Desulfation Cycle that is started on demand from the charger keypad display menu.

The Desulfation Cycle will take 8 to 18 hours, and is accomplished using a low charge current of approximately 5% of the battery capacity with virtually no ripple in the voltage or current wave forms. This charge creates a uniform field across the plates of the battery, where small soft sulfation crystals are present. The uniform charging field reverses the chemical reaction, dissolving the soft sulfation. For the larger soft sulfation crystals the uniform charging field reverses the chemical reaction, at first by decreasing the size and then dissolving them as they shrink.

Applying a uniform charge current additionally drives the reaction in the direction of maximizing the sulfuric acid content of the electrolyte, raising the specific gravity. The increase in specific gravity of 0.010 to 0.012, together with removal of the sulfation crystals, provides an increase of 5% to 10% in capacity over an unrecovered battery.

Battery performance is optimized when the resistance due to potential sulfation is dissolved and the plates are clean. Optimized batteries provide longer run times and have longer life expectancy.

[1]Battery University. *Sulfation and How to Prevent it* found at www. http://batteryuniversity.com