

Charging A Lead Acid Battery – What Happens Chemically:

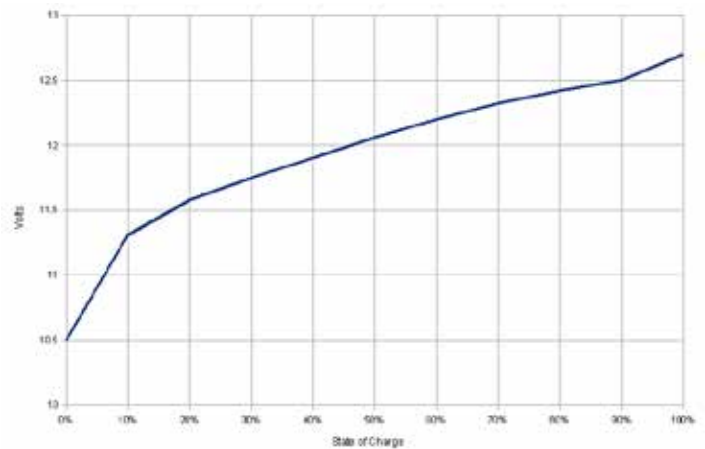
By Bob Gell - GELCOservices



The following description of the chemical reaction when charging a 20%Depth Of Discharge (DoD) automotive Lead Acid battery is presented as a “layman’s” view of what actually goes on with the chemical conversion of the Active Material (AM).

Charging Background Information:

Lead–acid batteries lose the ability to accept a charge when discharged for too long due to *sulfation*, the crystallization of lead sulphate. They generate electricity through a double sulphate chemical reaction. Lead and lead dioxide, the active materials on the battery’s plates, react with sulphuric acid in the electrolyte to form lead sulphate. The lead sulphate first forms in a finely divided, amorphous state, and easily reverts to lead, lead dioxide and sulphuric acid when the battery recharges. As batteries cycle through numerous discharges and charges, some lead sulphate is not recombined into electrolyte and slowly converts to a stable crystalline form that no longer dissolves on recharging. Thus, not all the lead is returned to the battery plates and the amount of usable active material necessary for electricity generation declines over time.



Sulfation occurs in all lead–acid batteries during normal operation. It impedes recharging; sulphate deposits ultimately expand, cracking the plates and destroying the battery. Eventually so much of the battery plate area is unable to supply current that the battery capacity is greatly reduced. In addition, the sulphate portion (of the lead sulphate) is not returned to the electrolyte as sulphuric acid. The large crystals physically block the electrolyte from entering the pores of the plates. Sulfation can be avoided if the battery is fully recharged immediately after a discharge cycle.



A white coating on the plates may be visible (in batteries with clear cases, or after dismantling the battery). Batteries that are sulphated show a high internal resistance and can deliver only a small fraction of normal discharge current.

Sulfation also affects the charging cycle, resulting in longer charging times, less efficient and incomplete charging, and higher battery temperatures.

Batteries which have sat unused for long periods of time can be prime candidates for sulphation. A long period of self-discharge allows the sulphate crystals to form and become very large.

A typical lead–acid battery contains a mixture with varying concentrations of water and acid. There is a slight difference in density between water and acid, and if the battery is allowed to sit idle for long periods of time, the mixture can separate into distinct layers with the water rising to the top and the acid sinking to the bottom. This results in a difference of acid concentration across the surface of the plates, and can lead to greater corrosion of the bottom half of the plates.

Voltage:

Starting with a battery which has been discharged until its voltage has decreased to 1.75v per cell – 10.50v in a 12 volt battery, we pass a current through it and cause the voltage to rise steadily. Fig.1 shows the changes in voltage during charge.

Ordinarily the voltage begins to rise immediately and uniformly. If, however, the battery has been left in a discharged condition for some time, or has been “over discharged,” the voltage rises very rapidly for a fraction of the first minute of charge and then drops rapidly to the normal value and thereafter begins to rise steadily to the end of the charge.

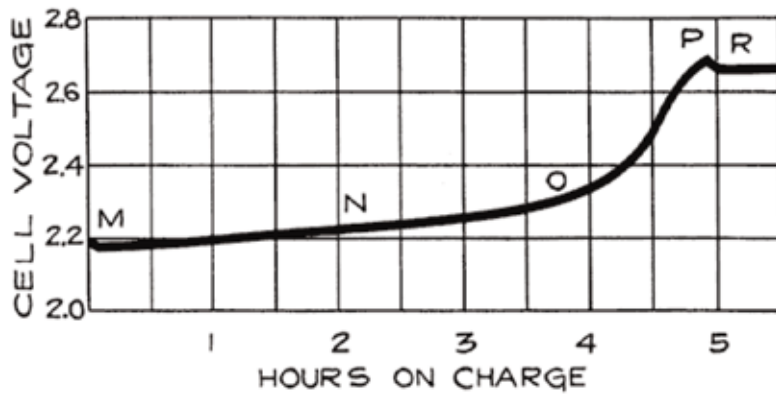
This rise at the beginning of the charge is due to the fact that the density of the acid in the pores of the plates rises rapidly at first, the acid thus formed being prevented from diffusing into the surrounding electrolyte by the coating of sulphate.

As soon as this sulphate is broken through, diffusion takes place and the voltage drops.

As shown in Fig.1, the voltage remains almost constant between the points M and N. At N the voltage begins to rise because the charging chemical reactions are taking place farther and farther in the inside parts of the plate, and the concentrated acid formed by the chemical actions in the plates is diffusing into the main electrolyte.

This increases the battery voltage and requires a higher charging voltage. At the point marked O, the voltage begins to rise very rapidly. This is due to the fact that the amount of lead sulphate in the plates is decreasing very rapidly, allowing the battery voltage to rise and thus increasing the charging voltage. Bubbles of gas are now rising through the electrolyte.

Fig;1



At P, the last portions of lead sulphate are removed, acid is no longer being formed, and hydrogen and oxygen gas are formed rapidly. The gas forces the last of the concentrated acid out of the plates and in fact, equalizes the acid concentration throughout the whole cell.

Thus no further changes can take place, and the voltage becomes constant at R at a voltage of 2.5v to 2.7v per cell – 15.0v to 16.2v. The charging device would now switch to “Float”, around 13.5-13.8volts.

Figure 2 is a table that relates the State of Charge to Depth of Discharge as referred to above. At a DOD of 90% the battery will indicate a OCV of 10.50volts – which is around 10%SOC.

