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Educational Material

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Using Lead-Acid Batteries

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Storage batteries do not store electrical energy, but convert electrical energy into chemical energy which is slowly accumulated as the charge progresses. A battery in use is said to be on discharge. During discharge, the chemical energy stored in the battery is converted into usable electrical energy.

A lead-acid storage battery consists of cells with positive and negative electrodes called plates, which are physically separated from each other and immersed in an electrolyte of sulfuric acid solution. The active materials of the electrodes are lead peroxide (PBS) for the positive plates, and sponge lead (Pb) for the negatives.

In a fully charged cell, the electrolyte has a specific gravity that varies from 1.260 to 1.285 (depending on type and manufacturer). When fully charged, each cell has a voltage of approximately two volts on open circuit. However, a cell may have a voltage from 2.12 to 2.70 volts when being charged.

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Charging The Cell:

The reaction that occurs in discharging the cell can be reversed, and it can be restored to its former charged condition by sending direct current through it in an opposite direction to the current flow on discharge. The active materials are restored to their respective conditions, and the electrolyte again

becomes a more concentrated sulfuric acid solution. Cell voltage rises as the two plates become increasingly different in composition and the specific gravity of the electrolyte increases. As an operating guide, to obtain the best performance and life from an R-E storage battery, the depth of discharge must not exceed 80% of the battery's rated capacity in ampere hours. It should be charged after each cycle or whenever the specific gravity of the electrolyte falls below 1.230. It is very important that proper ventilation be provided during charging to make certain that (1) the hydrogen gas given off toward the end of the charging process is dissipated, and (2) that individual cell electrolyte temperatures during normal operations do not exceed 115° F.

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Specific Gravity:

The term specific gravity describes the ratio of the density of electrolyte to the density of water. Electrolyte weighing 1.2 times as much as the same volume of water has a specific gravity of 1.200. The full charge gravity of a cell is a matter of design and depends on several factors. The specific gravity must be high enough to contain the amount of sulfuric acid necessary to meet the chemical needs of a cell. If the sulfuric acid content is too high, damage may result to the cell. The standard full charge gravity for lead acid batteries used in an R-E system is 1.250 to 1.285 depending on which type of battery you are using. Since the acid content of the electrolyte decreases linearly as the cell is discharged, the decrease in gravity is directly proportionate to the amount in ampere-hours taken out. The specific gravity at any point in the discharge indicates the depth of discharge, and can be translated into amp hours taken out. A cell having a full charge specific gravity of 1.280 and a final specific gravity of 1.130 has a gravity drop of 150 points.

Example: assume the specific gravity is 1.180 at 77°F at the end of a discharge. That is 100 points specific gravity below the full charge gravity, therefore, 100 ÷ 150=67% discharged of rated capacity. So if your battery were rated at 1000 amp hours you would have taken 670 amp hrs out of the battery. Use this formula and the readings from your amp/hr meter to get a good idea as to the battery's State Of Charge (SOC).

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Specific Gravity During Recharge

The rise of specific gravity is not uniform or proportional to the amount of charge returned in amp/hrs. During the early part of the charge , there is no gassing action to mix the electrolyte with the heavier acid being released from the positive plates. The heavier sulfuric acid will lie on the bottom of the cell container. A hydrometer reading which draws electrolyte from the top of the cell does not indicate the true gravity or actual state of charge. During the gassing portion of the charge the sulfuric acid mixes with the rest of the electrolyte in the upper portion of the cell. The gassing creates a movement upward; drawing heavy acid with it and the specific gravity rises rapidly to full charge value.

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Operation Of The Battery

There are several factors which affect the operation of the battery concerning its ability to deliver capacity and life expectancy. Many chemical reactions are affected by temperature, and this is true of the

reaction that occurs in batteries. The chemical reaction of a lead-acid battery slows down by the lowering of temperature which results in a loss of capacity. A battery will deliver 100% of capacity at 77ºF; at 20°F the battery only can deliver 74% capacity.

Excessive heat will contribute greatly to reducing battery life by corroding the positive grids and by excessive gassing which loosens active material pasted onto the positive grid. Overcharging is the most common contribution to excessive temperatures and gassing in a battery.

Consistent undercharging of a battery will gradually run down the cells and result in one or more cells becoming completely discharged before the others, and may become reversed. Capacity and life expectancy are greatly reduced by undercharging. Periodic equalizing charges that return the cells to a normal condition are part of good battery maintenance. Over discharging will also cause permanent damage to the battery. Recharging is more difficult and more time consuming. Often complete recharge is not attained and the undercharged battery is still providing power for your system. Consequently, it is over discharged even further, resulting in loss of capacity and pre-mature battery failure. Optimum battery life can be aided by limiting the Depth of Discharge (DOD) to 80%; to even further enhance battery life a 50% DOD can be used.

Good battery maintenance is necessary to protect life expectancy and capacity of your expensive battery. One key part of maintenance is record keeping. Without these records you are operating on a “gut feeling”; chemical reactions and gut feelings do not mix.

This information was taken directly from one of the leading battery manufacturer’s in the world. It applies to all makes and brands of Lead-Acid batteries; the only differences are in the full charge specific gravity and the final specific gravity.

You are welcome to use this information to help you in the operation of the battery you may already be using; doing so will help get maximum performance and life from any battery.

All this information may seem a bit overwhelming, but we feel you should know all the aspects involved in operating an R-E system before you spend your money. We at Northwest Energy Storage have put many years into the battery aspect of Solar Energy and feel it is the heart of any R-E system. In fact our name says it all.

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