The Technical Side

The Care & Feeding of Rechargeable Batteries-*Revisited*

Part II - Sealed Lead-Acid Batteries

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In the last *Technical Side* we covered proper care of nickel-cadmium rechargeable batteries. This article will focus on sealed lead-acid batteries used in GPS and auxiliary batteries.

BATTERY CHEMISTRY 101

We will start off by giving some background information and explaining some of the terms we will be using. Batteries do not make electricity but store an electron potential. All cells or batteries produce this potential from a chemical reaction called electrochemical storage. The chemical reaction begins when a resistance or load is connected to the two terminals. There are two types of cells: primary (P) or non-rechargeable and secondary (S) or rechargeable. Different chemical combinations are used, such as carbon-zinc (P), alkaline (P), lead-acid (S), nickel-cadmium (S), nickel-metal hydride (S) and lithium compounds (P & S). The reaction produced by these chemical combinations can be reversed in secondary cell batteries by sending electrons back through the battery. The original reaction can occur again, producing more electrons. In a lead-acid cell, the electrons are stored in the positive plate, the active element being lead dioxide (PbO^{2}). The negative plate is composed of pure lead, usually in a sponge form to facilitate the chemical reaction. The electrolyte, dilute sulfuric acid ($H^{2}SO^{4}$), completes the chemical reaction. As the cell discharges, the lead dioxide at the positive plate is converted to lead sulfate ($PbSO^{4}$), the lead sponge at the negative plate is also converted to lead sulfate ($PbSO^{4}$) and the sulfuric acid electrolyte is converted to water ($H^{2}0$). The process is reversed by forcing electrons back into the cell (charging). The chemical reactions are also reversed, converting the lead sulfate back into the respective lead dioxide, lead sponge and sulfuric acid.

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Let's explore some of the differences between a "gel cell" or sealed lead-acid battery and the typical "wet" (automotive or motorcycle) lead-acid battery. Both battery types use the same battery chemistry (lead dioxide, lead sponge and sulfuric acid electrolyte). The sealed lead-acid battery or gel cell differs from the wet or maintenance-free type in that the electrolyte is stabilized by combining it with a gelling agent or by using an absorbent plate separator. With the electrolyte stabilized, the sealed lead-acid battery can usually be stored, used (discharged) or charged in any position and is usually certified for air transport, as are nickel-cadmium batteries. There is generally no possibility for spillage of electrolyte in this type of battery as there is in a wet battery. One characteristic of the lead-acid battery chemistry is that the battery is adversely affected by high temperatures. The stabilized electrolyte makes the battery even more sensitive to high temperature and overcharging. The battery chemistry is most stable between the temperatures of 60 to 75 degrees Fahrenheit (16 to 24 degrees Celsius). For every 20F rise above 75F, the remaining service life of the battery is cut in half. Conversely, lower temperatures (above freezing) will lengthen the service life. Both the detrimental and beneficial results are due to the speeding up or slowing down of the chemical reaction by the change in the ambient temperature. Another side effect is that the capacity changes with temperature, as it does with most battery chemistries. The lead-acid chemistry will gain capacity above 75 degrees and lose capacity below 60 degrees. It is definitely a good idea to store and charge lead-acid batteries between 50 and 70 degrees. In other words, keep them cool.

CHARGING

Our first concern with a rechargeable battery is charging it. The goal is to reverse the chemical reaction without inducing side effects such as overcharging the battery. There are several recharging methods. The most common and least expensive charger uses the constant current charging method. A constant current charger maintains a small constant amount of current through the battery for a long period of time. The total amount of current delivered depends on the battery capacity and the charge time. Constant current chargers are designed for a 12 to 16-hour charge period. Another common charge technique uses constant voltage. As the name implies, a constant voltage charger maintains a set voltage across the battery. When a dead battery is first connected to this charger, a high initial charge current flows into the battery. As the battery charges, the current tapers off. A constant voltage charger usually finishes this cycle in two to four hours and is terminated by a timer to prevent overcharging. This type of charger is somewhat of a guessing game. Do not use an automotive type charger to recharge sealed lead-acid batteries as the voltage output for automotive batteries is too high and can definitely cause overcharging.

More sophisticated chargers will use a

combination of the constant voltage and constant current methods. A temperature compensation circuit is also provided in the charger to sense ambient temperature. This provides a method to vary the charge current and voltage as the charging environment temperature changes. When the charge is started, a moderately high current is supplied to the battery. As the voltage rises, the current lowers until it reaches a value that ends this bulk charge. The circuitry then lowers the voltage and current to a proper maintenance level. This stage of charging will continue until the battery is removed. The maintenance current is needed to make up for self-discharge, which occurs to some extent in all battery types.

USING THE BATTERY

The next thing we do with our battery is discharge it. This part is easy - we just use our total station, GPS receiver, data collector, radio, or other piece of portable electronic equipment. But what happens when the battery doesn't perform like it is supposed to? Rechargeable batteries are famous for having problems. They get overcharged, undercharged, develop sulfation, develop shorted or open cells, the list goes on. Let's address these problems and explore some solutions. My battery died, what happened?

Overcharging batteries shortens their service life. Once the plate material is completely reformed (battery is charged), continued charging can result in excess gas generation and diminished capacity. When a lead-acid battery is completely charged, continued charging causes the electrolyte to break down and form hydrogen and oxygen gases. This is the "boiling" that we see when charging an automotive battery at a high rate near the end of a timed recharge. Two bad things are happening at this point:

(1) An explosive gas mixture is forming in the battery and in the case of a sealed lead-acid battery, heat and pressure are building. If the pressure becomes great enough, the sealed one-way valves on the battery will open and vent the excess gas presure and possibly liquid electrolyte.

(2) In an unsealed wet battery, electrolyte is vaporized or converted to hydrogen and oxygen and is lost but may be replaced. In a mainte nance-free or sealed battery the electrolyte is lost and cannot be replaced. In all lead-acid batteries, loss of electrolyte means loss of capacity and service life.

A word of caution:
<u>ALL</u> lead-acid batteries can produce hydrogen and oxygen gases!

A word of caution: **ALL** lead-acid batteries can produce hydrogen and oxygen gases! Never charge lead-acid batteries in a sealed area or container. Always charge lead-acid batteries with adequate ventilation and avoid making or breaking connections at the battery to avoid an electrical discharge (sparks, arcs or shorts). Connect the charger to the battery system before powering up or plugging in the charger. Another caution for discharged lead-acid batteries: Remember that the electrolyte at this point is mostly water and will freeze at a higher temperature (15 to 20F) than a fully charged battery.

Lead-acid batteries can suffer from a condition called sulfation. Lead sulfate is normally produced as the battery discharges and is reconverted as it recharges. (Remember Battery Chemistry 101?) If a battery is left for a long period in a discharged or partially charged state or is never fully recharged, the lead sulfate can harden and resist conversion back to lead dioxide and sponge lead. This results in a loss of capacity which may or may not be reversible. Make sure that the battery is fully charged on most cycles.

Sealed lead-acid batteries generally will not tolerate repeated deep discharges. A 12-volt battery should not be discharged below about 10.5 to 10.7 volts (1.75 volts per cell x 6 cells). If a battery is completely discharged, all of the reactive materials are converted and it may be very difficult to reverse the chemical reaction. Some batteries are designed with a plate size imbalance and/or catalyst to help control gas generation and aid in deep cycle recharging.

Shorted cells are caused by physical contact between the plates, usually caused by separator failure, heat distortion or vibration and shock. Open cells can be caused by loss of electrolyte, by vibration or shock damage which causes a break in the cell connector. These problems are seldom repairable.

As with nickel-cadmium batteries, full use of the battery capacity and a full charge is the best way to maintain full energy reserves. If you suspect that the battery capacity has decreased, a charge/discharge/charge cycle with current monitoring should be performed. This test is best performed by a repair technician using equipment that profiles the battery when charging and discharging. The test equipment can show the exact amount of charge and discharge current. Connection to a computer generates a graph of the charge and discharge curves, with current and voltage related to time. The result is compared to the profile for a new battery and allows you to decide whether or not to replace your battery. We have given you the basics of rechargeable batteries in these two columns. The knowledge that we have presented is but a small portion of the information available and like all subjects is given to interpretation and personal experience.

If you have questions or would like to discuss this subject further, contact us at The Technical Side, 1562 Linda Way, Sparks, NV 89431, fax us at (702) 359-6693, or e-mail us at cothrungix.netcom.com. Visit our web site at <http://ourworld.compuserve.com/homepages/cothrun/>