ERC-East / Batteries, Automotive vs Marine
"More Information Than You Ever Wanted To Know"
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During the September 2005 St. Louis Area Preparedness Net (now Bridgeton ERC) Semi-Annual Breakfast & Training we had a very lively discussion about deep cycle marine batteries - based on that discussion Don KC9KBB (VE3CDP/W9) searched the Internet and with the exception of the next paragraph all the snippets are from the information he sent me. There is a section toward the end about re-charging that everyone with a battery should read!!

Each battery comes with a manufacturing date - the date is usually on a sticker on the side of a battery - the rule of thumb is do not buy a battery that is three months old or older - pass on it and find one that is less than 3 months old if at all possible - as with any deep cycle battery charge it first before use with a battery charger that is recommended by the manufacturer - some marine / deep cycle batteries require a auto charger, some a deep cycle charger. Using the wrong can ruin a deep cycle battery - see the section on recharging.

A car's battery is designed to provide a very large amount of current for a short period of time. This surge of current is needed to turn the engine over during starting. Once the engine starts, the alternator provides all the power that the car needs, so a car battery may go through its entire life without ever being drained more than 20 percent of its total capacity. Used in this way, a car battery can last a number of years. To achieve a large amount of current, a car battery uses thin plates in order to increase its surface area.

A deep cycle battery is designed to provide a steady amount of current over a long period of time. A deep cycle battery can provide a surge when needed, but nothing like the surge a car battery can. A deep cycle battery is also designed to be deeply discharged over and over again (something that would ruin a car battery very quickly). To accomplish this, a deep cycle battery uses thicker plates.

A car battery typically has two ratings:

CCA (Cold Cranking Amps) - The number of amps that the battery can produce at 32 degrees F (0 degrees C) for 30 seconds

RC (Reserve Capacity) - The number of minutes that the battery can deliver 25 amps while keeping its voltage above 10.5 volts Typically, a deep cycle battery will have two or three times the RC of a car battery, but will deliver one-half or three-quarters the CCAs. In addition, a deep cycle battery can withstand several hundred total discharge/recharge cycles, while a car battery is not designed to be totally discharged.

The following gives much greater detail about batteries............

Can The Lead-acid Battery Compete In Modern Times?

The answer is YES. Lead-acid is the oldest rechargeable battery in existence. It has retained a market share in applications where newer battery chemistries would either be too expensive or the upkeep would be too demanding. There are simply no cost-effective alternatives for such applications as wheelchairs, scooters, golf carts, people movers and UPS systems.

Invented by the French physician Gaston Planté in 1859, lead-acid was the first rechargeable battery for commercial use. Today, the flooded lead-acid battery holds a domineering position in automobiles, forklifts and large uninterruptible power supply (UPS) systems.

During the mid 1970s, researchers developed a maintenance-free lead-acid battery that could operate in any position. The liquid electrolyte was transformed into moistened separators and the enclosure was sealed. Safety valves were added to allow venting of gas during charge and discharge. (The Stowaway XLT at Sam's)

Driven by different market needs, two lead-acid systems emerged: the small sealed lead-acid (SLA), also known under the brand name of Gelcell, and the large valve-regulated-lead-acid (VRLA). Technically, both batteries are the same. (Engineers may argue that the word 'sealed lead acid' is a misnomer because no rechargeable battery can be totally sealed.)

Unlike the flooded lead acid battery, both SLA and VRLA are designed with a low over-voltage potential to prohibit the battery from reaching its gas-generating potential during charge. Excess charging would cause gassing and water depletion. Consequently, these batteries can never be charged to their full potential.

Finding the ideal charge voltage limit is critical. Any voltage level is a compromise. A high voltage limit (above 2.40V/cell) produces good battery performance but shortens the service life due to grid corrosion on the positive plate. The corrosion is permanent. A low voltage (below 2.40V/cell) is safe if charged at a higher temperature but is subject to sulfation on the negative plate.

Lead-acid is not subject to memory. Leaving the battery on float charge for a prolonged time does not cause damage. The self-discharge is about 40% per year, one of the best on rechargeable batteries. In comparison, nickel-cadmium self-discharges this amount in three months. Lead-acid is relatively inexpensive to purchase but the operational costs can be more expensive than the nickel-cadmium if full cycles are required on a repetitive basis.

Lead-acid does not lend itself to fast charging. Typical charge time is 8 to 16 hours. The battery must always be stored in a charged state. Leaving the battery in a discharged condition causes sulfation, a condition that makes the battery difficult, if not impossible, to recharge.

Unlike nickel-cadmium, the lead-acid does not like deep cycling. A full discharge causes extra strain and each cycle robs the battery of a small amount of capacity. This wear-down characteristic also applies to other battery chemistries in varying degrees. To prevent the battery from being stressed through repetitive deep discharge, a larger battery is recommended.

Depending on the depth of discharge and operating temperature, the sealed lead-acid provides 200 to 300 discharge/charge cycles. The primary reason for its relatively short cycle life is grid corrosion of the positive electrode, depletion of the active material and expansion of the positive plates. These changes are most prevalent at higher operating temperatures. Cycling does not prevent or reverse the trend.

The optimum operating temperature for the lead-acid battery is 25°C (77°F). As a guideline, every 8°C (15°F) rise in temperature will cut the battery life in half. VRLA, which would last for 10 years at 25°C (77°F), will only be good for 5 years if operated at 33°C (95°F). Theoretically the same battery would endure a little more than one year at a desert temperature of 42°C (107°F).

Among modern rechargeable batteries, the lead-acid battery family has the lowest energy density, making it unsuitable for handheld devices that demand compact size. In addition, performance at low temperatures is poor.

The sealed lead-acid battery is rated at a 5-hour discharge or 0.2C. Some batteries are rated at a slow 20-hour discharge. Longer discharge times produce higher capacity readings. The lead-acid performs well on high load currents. During these pulses, discharge rates well in excess of 1C can be drawn.

In terms of disposal, the lead-acid is less harmful than nickel-cadmium but the high lead content and the electrolyte make the lead-acid environmentally unfriendly.

Advantages:

- Inexpensive and simple to manufacture.
- Mature, reliable and well-understood technology - when used correctly, lead-acid is durable and provides dependable service.
- The self-discharge is among the lowest of rechargeable battery systems.
- Low maintenance requirements - no memory; no electrolyte to fill on sealed version.
- Capable of high discharge rates.

Limitations:

- Low energy density - poor weight-to-energy ratio limits use to stationary and wheeled applications.
- Cannot be stored in a discharged condition - the cell voltage should never drop below 2.10V.
- Allows only a limited number of full discharge cycles - well suited for standby applications

that require only occasional deep discharges.
- Lead content and electrolyte make the battery environmentally unfriendly.
- Transportation restrictions on flooded lead acid - there are environmental concerns regarding spillage. Thermal runaway can occur with improper charging.

A Short Primer Of Lead-Acid Battery Types

The common types of lead-acid batteries are presented here in order of worst to best. The "life expectancies" that we've listed for various battery types are the average that we've learned to expect with only reasonable care over the years. Please don't take these figures as a performance guarantee. We've dealt with novices who can destroy the best battery within six months, but we've also been blessed by meeting a few super conscientious people who can make their batteries last more than twice the average.

Car Batteries:

The most common type of lead-acid battery is the automotive battery, sometimes called "starting batteries." This type of lead-acid battery has many thin lead plates and is designed to deliver hundreds of amps for a few seconds to start a car. Starting batteries are only designed to cycle about 10% to 15% of their total capacity and to recharge quickly from the alternator after discharging. They are not designed for the deep cycle service demanded by remote home power systems, and will fail fairly quickly when used in a deep-cycling application.

"RV" or "Marine" Deep-Cycle Batteries:

This generic category includes most of the 12-volt batteries that Wal-Mart, Sears, K-Mart, etc. sell as "deep cycle," "RV," or "marine" batteries. They are always 12-volt, and usually have between 80- and 160-amp-hour capacity. These batteries are a compromise between starting batteries and true deep-cycle batteries, as many of them are actually put into starting battery service by RV users who simply don't know better. They will give far better deep-cycle service than starting batteries, and may be the ideal choice for a beginning system that you plan to expand later. Life expectancy for these batteries is typically two to three years.

"Telephone Company" or Lead-Calcium Batteries:

During the past 15 years telephone companies have been upgrading much of their switching equipment from the old style 48-volt relay type to newer solid-state equipment. When a telephone station is changed over, the huge battery bank that ran the old equipment is sold or recycled. Occasionally these shallow-cycle lead-calcium batteries are used in remote power systems. The typical life expectancy for these batteries is 15 to 20 years, although there are some on the market that claim 50 years or more. These batteries can be used in remote power systems, if you treat them carefully. These are shallow-cycle batteries that rarely experienced more than a 15% cycle in telephone service. If you are careful never to discharge them deeply, these batteries can give years of excellent service.

While phone company batteries can sometimes be found cheap, or even free for the hauling, their sheer weight and size make them difficult to contend with. Some of these batteries weigh close to 400 pounds per 2-volt cell. Because cycle capacity is limited to 15% or 20%, you have to buy, move, and install five or six times more battery mass than is required for true deep-cycle batteries. Remember, that phone company battery may be rated at 1,680 amp-hours, but you can only use 20% of that capacity or 336 amp-hours, which isn't much by renewable energy standards. Unless you can find these batteries almost free, we don't recommend them.

Sealed Batteries:

Sealed batteries have the acid either gelled or put into a sponge-like glass mat. They have the advantage/disadvantage of being completely liquid-tight. They can operate in any position, even sideways or upside down, and will not leak acid. Because the electrolyte moves more slowly, these batteries cannot tolerate high rates of charging or discharging for extended periods, although their thinner plates will allow high rates for a short time. Their sealed construction, which makes them ideal for some limited applications, makes it impossible to check individual cell conditions with a hydrometer. Although these cells are "sealed," they do have vents to prevent pressure build-up in case of gassing. Many PV charge controls will push charging voltage too high for sealed batteries. Premature failure will result due to loss of water vapor. We recommend sealed batteries only in situations where hydrogen gassing during charging cannot be tolerated, or the battery is going to be moved and handled a great deal, or in conditions where the battery needs to fit into unique, tight spaces. Boats, UPS computer power supplies, and remote expeditions are the most common uses. Special lower voltage charge controls must be used with these batteries. Life expectancy is two to five years for most AGM (absorbed glass mat) batteries, and five to ten years for the higher quality, but more difficult to manufacture, gel cell batteries. Most sealed batteries are AGM types.

True Deep-Cycle Batteries:

True deep-cycle batteries are specifically designed for energy storage and deep-cycle service. They tend to have larger and thicker plates. This is the type of battery that is best suited for use with renewable energy systems. They are designed to withstand having a majority of their capacity used before being recharged. They are available in many sizes and types, the most common being 6-volt and 2-volt configurations for ease of movement. Once in place, the multiple batteries are series and/or parallel connected for your basic system voltage. These batteries are built to survive hundreds or even thousands of 80% cycles, though for best life expectancy we recommend 50% as the normal maximum discharge. This leaves you a 30% reserve for real emergencies. Never use the bottom 20% unless you like buying new batteries. The less deeply you regularly cycle your batteries, the longer they will last. The three most commonly available batteries within this group are the "golf cart" types with a three- to five-year life expectancy, the L-16 series with a seven- to ten-year life expectancy and industrial forklift-type batteries with a 15- to 20-year life expectancy. Deep-cycle batteries are usually your best battery investment.

We often recommend the golf cart types for small to medium-sized beginning systems. They make relatively inexpensive "trainer" batteries. Do your learning, make your mistakes, and in three to five years, when they wear out, you'll be in a much better position to judge your needs and what you're willing to pay for them.

New Technologies?

Compared to the electronic marvels in the typical renewable energy package, the battery is a very simple, relatively antiquated, electrochemical package. Tremendous amounts of research have been directed lately into energy storage technology. Auto manufacturers are desperately searching for a lightweight battery with high energy density and low cost - The Magic Battery. There are currently several dozen battery technologies under intense development in the laboratory. Several of these new technologies are bearing fruit now for cell phones, laptops, and hybrid vehicles, but are still far too expensive for the amount of energy storage required in a renewable energy system.

The possibilities of lead-acid technology are far from tapped out. Lead-acid batteries are also in the laboratory. This old dog is still capable of learning some new tricks. For now we must coexist with traditional battery technology, a technology that is nearly 100 years old, but is tried and true and requires surprisingly little maintenance. The care, feeding, cautions, and dangers of lead-acid batteries are well understood. Safe manufacturing, distribution, and recycling systems for this technology are in place and work well.

Could we say the same for a sulfur-bromine battery?

People Kill More Deep Cycle Batteries With Poor Charging Practices, Than Die Of Old Age!

During the normal discharge process, lead and sulfur combine into soft lead sulfate crystals are formed in the pores and on the surfaces of the positive and negative plates inside a lead-acid battery. When a battery is left in a discharged condition, continually undercharged, or the electrolyte level is below the top of the plates, some of the soft lead sulfate re-crystallizes into hard lead sulfate. It cannot be reconverted during subsequent recharging. This creation of hard crystals is commonly called permanent or hard **"sulfation."** When it is present, the battery shows a higher voltage than it's true voltage; thus, fooling the voltage regulator into thinking that the battery is fully charged. This causes the charger to prematurely lower it's output voltage or current, leaving the battery undercharged. Sulfation accounts for approximately 85% of the lead-acid battery failures that are not used at least once per week. The longer sulfation occurs, the larger and harder the lead sulfate crystals become. The positive plates will be **light brown** and the negative plates will be dull, off white. These crystals lessen a battery's capacity and ability to be recharged. This is because deep cycle and some starting batteries are typically used for short periods, vacations, weekend trips, etc., and then are stored the rest of the year to slowly self discharge. Starting batteries are normally used several times a month, so sulfation rarely becomes a problem unless they are undercharged or the plates are not covered with electrolyte.

As a consequence of parasitic load and natural self-discharge, permanent sulfation occurs as the lead-acid battery discharges while in long term storage. *(Parasitic load is the constant electrical load present on a battery while it is installed in a vehicle even when the power is turned off. The load is from the continuous operation of appliances, such as a clock, security system, maintenance of radio station presets, etc.)* While disconnecting the negative battery cable will eliminate the parasitic load, it has no effect on the natural self-discharge of a car battery. Self discharge is accelerated by temperature. Thus, sulfation can be a huge problem for lead-acid batteries not being used, sitting on a dealer's shelf, or in a parked vehicle, especially in **HOT** temperatures.

Car and deep cycle lead-acid batteries are perishable!

How Can I Tell If my Battery Has Permanent Sulfation?

Chances are that your battery has some permanent sulfation, if it will not "take" or "hold" a charge and exhibits one or more of the following conditions:

- If your wet (flooded) Standard (Sb/Sb) or wet (flooded) Low Maintenance (Sb/Ca) battery has been not been recharged for over three months, especially if the temperature in the storage area was consistently over 77 degrees F (25 degrees C). (Six months for wet Maintenance Free (Ca/Ca) or one year for VRLA AGM or Gel Cell.)
- While recharging in a well ventilated area, the ammeter does not drop to below 2% (C/50) of the twice the amp hour capacity of the battery divided by the charging rate in hours and the battery is warm or hot. For example, if you have a 50 AH battery and a ten amp charger, a discharged battery should be fully charged within 10 hours (2 x 50 AH/10 amps = 10 hours).
- If the Specific Gravity is low in all cells after the battery been on a charger for a long time.
- If the temperature compensated absorption charging voltage is correct and the battery is gassing or boiling excessively.
- Poor performance or low capacity.

How do I prevent permanent sulfation?

The best way to prevent sulfation is to keep a lead-acid battery **fully charged** because lead sulfate does not form. This can be accomplished three ways. The best solution is to use a charger or desulfator in a well ventilated area that is capable of delivering a continuous "float" charge at the battery manufacturer's recommended float or maintenance voltage for a fully charged battery or a desulfating pulse. 12-volt batteries, depending on the battery type, usually have fixed float voltages between 13.2 VDC and 13.8 VDC, measured at 80° F (26.7° C) with an accurate (.5% or better) digital voltmeter. Based on the battery type you are using, charging can best be accomplished with a microprocessor controlled, three stage (for AGM or Gel Cell batteries) or four stage (for wet batteries) "smart" charger. If the battery is fully charged,by voltage-regulated float charger to "float" or maintain the full charge. **A cheap, unregulated "trickle" charger or manual two stage charger can overcharge a battery and destroy it.**

A second technique is to use a regulated solar panel or wind or water generator designed to float charge the battery. This is a popular solution when AC power is unavailable for charging. A desulfator can be used in conjunction with this method.

A third and less desirable method is to periodically recharge the battery in a well ventilated area when the State-of-Charge drops to 80%. Maintaining a high State-of-Charge (SoC) tends to prevent irreversible sulfation. The recharge frequency is dependent on the parasitic load, temperature, the battery's condition, and plate formulation (battery type). **Temperature matters!** Lower temperatures slow down electro chemical reactions and higher temperatures speed them up. A battery stored at 95° F (35° C) will self-discharge twice as fast than one stored at 75° F (23.9° C).

How do I recover sulfated batteries?

Here are three methods to try to recover permanently sulfated batteries:

- Light Sulfation / Check the electrolyte levels and apply a constant current at 2% of the battery's RC or 1% of the AH capacity rating for 48 to 120 hours at 14.4 VDC or more, depending on the electrolyte temperature and capacity of the battery. Cycle (discharge to 50% and recharge) the battery a couple of times and test its capacity. You might have to increase the voltage in order to break down the hard lead sulfate crystals. If the battery gets above 125° F (51.7° C) then stop charging and allow the battery to **cool** down before continuing.

- Heavy Sulfation / Replace the old electrolyte with distilled, deionized or demineralized water, let stand for one hour, apply a constant current at four amps at 13.8 VDC until there is no additional rise in specific gravity, remove the electrolyte, wash the sediment out, replace with fresh electrolyte (battery acid), and recharge. If the specific gravity exceeds 1.300, then remove the new electrolyte, wash the sediment out, and start over from the beginning with distilled water. You might have to increase the voltage in order to break down the hard lead sulfate crystals. If the battery gets above 125° F (51.7° C) then stop charging and allow the battery to **cool** down before continuing. Cycle (discharge to 50% and recharge) the battery a couple of times and test capacity. The sulfate crystals are more soluble in water than in electrolyte. As these crystals are dissolved, the sulfate is converted back into sulfuric acid and the specific gravity rises. This procedure will only work with some batteries.

- Desulfators / Use a desulfator also known as a pulse charger. A list of some of the desulfator or pulse charger manufacturers is available on the “Battery References Links List” at http://www.batteryfaq.org. Despite manufacturer's claims, some battery experts feel that desulfators and pulse chargers do not work any better at removing permanent or preventing sulfation than do constant voltage chargers.