Boat Battery Basics

Tired of Replacing Batteries Every Two Years?
A better Understanding of Batteries Will Help Resolve Your Problems

by David Pascoe

One of the most common problems I run into on surveys is dead or severely depleted batteries. The usual reason why boat batteries are dead is due to having the wrong type, size or quality to meet the vessel's demands. Truly good batteries are expensive and there are few boat builders that provide good batteries with new vessels; usually the quality is minimal, the amount of power inadequate, and the type ill-suited.

The subject of batteries can be rather complex, but I'm sure most boat owners would rather not know too much about the details of how batteries work (or fail to work). The discussion of batteries can be divided into two major topics, battery construction and application, and charging. This essay deals mainly with battery construction and application, and will help you gain a better understanding of what type is best for your application, as well as what is needed to maintain them for longest service life and reliability. Application means the type of boat you have, how it is used, and the kinds of equipment on it.

Until the recent advent of electronic chargers we had big problems with ferroresonant chargers overcharging and damaging batteries. Now, to the best of my knowledge, all electronic chargers provide the basic 3 stage charging with electronic sensing that prevents overcharging. Therefore, if you have an old charger and are having premature battery failure problems, you'd best replace the unit. Symptoms of overcharging are hot batteries and unusual fluid loss.

System Designs

Batteries lie at the heart of all pleasure craft DC electrical systems but there is wide variation on how DC systems are set up, meaning what purpose is assigned to each bank. The vast majority of all boats have relatively simple 12 volt systems consisting of banks of one, two or four batteries connected in parallel. Larger yachts may have 24 or 32 volt systems. In the standard, or I should say typical marine system, each bank is used for starting one engine, but is also wired to a battery selector switch. The selector switch may have positions marked 1, 2 or ALL. Other switches are marked ON/OFF, in which case bank source cannot be changed. In most cases the selector switch controls which bank runs the house system. In older boats, engine starting may be controlled by the switch. The ABYC standard requires all boats to have a master shut off switch, but not a selector switch.

Battery parallel switches join two batteries together in parallel (doubles amperage, not voltage), even if both are low, will often start an engine that won't start on one bank alone. This facilitates the starting circuit alone and will have no effect on the house system.

Boats which have a selector switch are usually set up in such a way that the source for the house system can be selected via the switch. In many, if not most, later model boats the house system is permanently wired to both banks. With older and particularly larger boats, there is likely to be one bank dedicated as the house bank.

Generators should have a separate starting battery so that if the main banks go dead, the generator can still be started. This is not always the case.

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Unfortunately, batteries are made in so many configurations and types that there are no quick and easy answers for those that desire quick answers. This essay is the culmination of several weeks worth of research into battery fundamentals, standards and testing. It is not a technical treatise of scientific exactitude because were I do so, this essay would end up dozens of pages long and I'm sure you have no interest in reading that.

This essay is intended to be of most benefit to those of you who suffer from the problems of premature battery failure and all-to-frequent replacement. If you're ever wondered why there is so much conflicting information about batteries, it is because not many people bother to take the time to learn, including many people that sell batteries. Amongst experts, there is wide agreement about performance of various types because actual performance is easily proven.

Contrary to popular misconception, the so-called "maintenance-free" battery is anything but. The only difference between this type and those not so designated is that you don't have to top off the electrolyte (add water) when it evaporates, but batteries still need to be maintained in other ways as they will not function properly when ignored. Sealed batteries are not really sealed because all wet cell batteries have to be vented in order to discharge the build up of pressure during charging. Thus, even maintenance-free batteries can loose fluid, especially as a result of over charging. The primary difference is that one cannot add water to a "sealed" battery, though some will leak if laid over.

These batteries are also not maintenance free because they will naturally discharge themselves over time at a rate of anywhere from 1% to 15% per month, depending on type. These batteries should not be left uncharged month after month, but should be maintenance charged on a regular basis. Total discharge will destroy a battery so that it will never take a full charge again.

Most inboard powered boats are fitted with shore power systems and battery chargers to keep the batteries charged. Up until recently all battery chargers were the ferroresonant type capable of "trickle" charging, that is, supplying a very low charge rate sufficient to keep the batteries up to snuff. The problem with those older chargers was that they had a bad tendency to overcharge and boil all the electrolyte away which damages and eventually ruins the battery. Overcharging is deadly to gel cells.

The introduction of electronic, 3-stage chargers in recent years has been a vast improvement in battery maintenance because these chargers are able to sense when the battery cannot take any more charge and then shut off.

Installation Requirements

Batteries should be installed in a dry location and at a sufficient height above the bilge that a hull flooding incident will not immediately submerge the batteries and short them out. Batteries mounted close to the bottom of the hull run this risk.

Batteries generate hydrogen gas while charging; hydrogen gas is highly corrosive to most metals and particularly rubber products. Thus, hoses, wiring, fuel and oil lines should never be located ABOVE batteries as this gas is lighter than air and will rise.

Regardless of type, it is highly recommended that batteries be mounted in rugged, covered plastic boxes specially designed for this purpose. This is to contain the inevitable sulfuric acid leaks, this acid being very damaging to all organic materials (clothing, wood) as well as most metals.

Battery Types

All lead/acid batteries are not basically the same. The basic types are starting or automotive, marine and deep-cycle batteries. That last category name has been seriously abused in recent years by marketers of hybrid batteries that are not true deep-cycle but a cross between a starting battery and a deep-cycle. These will have plates that are slightly thicker than starting batteries, but much thinner than deep cycle batteries.

The most important criteria that determines battery type and performance is the thickness and composition of the battery plates, the factor that most affects cost.

Battery service life is primarily determined by how many times it is cycled, and whether it has been designed to withstand frequent and significant discharging. Cycling means each period of discharging and subsequent recharging. Equally important is how far a battery is discharged before recharging. Automotive batteries are designed to tolerate discharges at around 5% before recharging and will soon fail if deeply discharged, whereas deep cycle batteries are designed to discharge to 50% or more without being harmed.

Starting/Automotive As its name implies, starting batteries are used to start and run engines. These have different characteristics since engine starting requires very high bursts of amperage for short periods. Starting or automotive batteries have have a large number of very thin (0.40"), highly porous plates so as to provide the maximum surface area to yield that high high burst amperage. The down side of this type of battery construction is that it does not tolerate deep discharging well, and will fail after a relatively small number of deep discharge cycles (about 400 versus 2,000 for deep cycle). Starting batteries are commonly found in outboard and many entry level boats.

These are also frequently inappropriately labeled as "marine" batteries or auto/marine. Automotive batteries are meant to be constantly charged by an alternator so as to avoid discharge rates more than 5%. Starting batteries are usually rated by CCA (cold cranking amps) or simply CA (cranking amps), and more often than not have NO rating imprinted on the label. One method of identifying starting batteries is by their price: they are always much lower priced than true marine or deep-cycle batteries, as well as their lack of any rating. *There are literally hundreds of brand names of this type and many are of very poor quality*.

Marine It seems as if every battery manufacturer today sells "marine" batteries but, as mentioned earlier, many such take considerable liberty with the term. Some marine batteries are deep cycle, others are hybrids, while others are pure hokum. True marine batteries are designed for dual use of engine starting and house service and are therefore hybrids (not true deep cycle). These will have spongy, porous plates that are *significantly thicker* than automotive batteries. They will be larger and heavier than auto batteries. A true marine battery will tolerate up to 50% discharge, whereas a deep-cycle and industrials tolerates up to 80%, whereas an auto battery will quickly die at such discharge rates. Numerous batteries found in small boats will be labeled "auto/marine" and the only way to tell the type is by cutting it open and examining the plates unless you are buying a reputable brand, but it's still a pretty good bet that any battery so labeled isn't going to be very good. *There are also very many brand names of this type, and also many of low quality.*

Deep-Cycle These batteries are distinguished by having much thicker plates (1/4" or 0.270" for Surette), nearly seven times thicker than an automotive battery, but high quality batteries will have solid lead plates versus others made of a lead powder composite. Lead powder plates allow for much more rapid charging but also deteriorate much faster, whereas solid or more dense and thicker plates are slower charging but have much longer service life.

Deep cycle batteries withstand greater abuse and thousands of charging cycles and have much greater service life than the other two types. They do not, however, have as great cranking or burst power, being designed to provide power over longer periods of time. Best for use with inverter systems. They are identifiable by their cost of 2-3 times that of other types and 20 hour AH ratings. True deep cycle batteries are usually only found in larger, higher end boats and yachts due to their greater cost, as well as the huge power demands of larger boats. *The number of brand names of this type is relatively small since the cost is higher. Good quality ones are usually not found in discount stores or mass retail outlets.*

When deep cycle batteries are used in boats, it is necessary to have considerably greater amperage than that required by the engine starter. This is almost never a problem since these batteries are used in banks of more than one battery per bank. When you get up to sizes like 4D and 8, 125 & 250 AH respectively, even a single battery is more than adequate because the amperage is so high.

Golf Cart batteries are generally a quasi-deep cycle similar to marine, and though not as good as batteries with solid plates, they are better than the auto/marine types. Usually set up in banks of six volt batteries, these have a greater number of plates to provide longer periods of use under a constant power demand and deep discharging. T-105, US2200 and GC-4 are common identifiers. These batteries can discharge up to 80% without being damaged. They are not better for use with inverters than true deep cycle batteries.

RV Batteries This name has recently begun appearing on batteries found in boats. Within the industry, there is no common battery type known as "RV" but it can be assumed that, like the "auto/marine" designation, it is a hybrid somewhere between a cranking and deep-cycle battery.

Industrial Batteries "Industrial" or "commercial" has long been used as a designation for deep cycle batteries used in fork lifts, sweepers, floor cleaners and similar battery powered machinery. Similar to golf cart but usually true deep cycle types with much heavier and pure lead plates up to around 0.270" thick. These batteries can discharge up to 80% without being damaged.

Yet another type name has crept into the lexicon recently, is the RV type. Most RV types sold are cranking batteries or hybrids as indicated by their higher cranking power but lower reserve power.

Obviously, the deep-cycle is the preferred battery type for marine use but for it's one drawback of being less able to provide high cranking power. This is overcome simply by increasing battery size.

Gel Cells

The primary difference between gel cells and flooded acid batteries is that the electrolyte in gel cells has been gelled by the addition of silica gel, turning the liquid into a thickened mush the same way napalm is gelled gasoline. Once hailed as the messiah of marine batteries, gel cells have since revealed their weakness to being damaged by heat and overcharging as these batteries cannot be fast charged by ordinary fast chargers and require much slower charging rates. Gel batteries sustain a far lower number of charging cycles than wet cell batteries, 2,000 versus 500 cycles for gel cells.

This makes them less than ideal for marine applications. Additionally, they do not hold up well in hot engine rooms. The added cost has not proved worth the meager benefit of not spilling acid. Despite the common misperception, the gel cell electrolyte does evaporate over time.

AGM Batteries

AGM stands for Absorbed Glass Mat which contains the electrolyte absorbed in a mesh of Boron-Silicate glass fibers. Thus there is no fluid electrolyte to leak or spill nor will they suffer from freeze damage. There are two big advantages of this type. First, it can be charged with conventional chargers without fear of damage from modest overcharging. Second, water loss is reportedly reduced by 99% because hydrogen and oxygen are recombined within the battery. Further, this type has a modestly lower self discharge rate of 1-3% versus up to 15% with standard lead-acid batteries. The AGM is a true no maintenance battery. It otherwise has similar characteristics as the standard lead-acid battery. They have yet to see much use in boats, probably due to the higher cost. Widely used in battery back up power systems and solar systems.

The down side is the cost of around 2-3 times comparable standard batteries. Thus their greatest benefit is for installations where it is hard or impossible to ventilate charging fumes such as the interiors of sail boats.

Sealed or maintenance-free batteries

This battery type has sealed, but still vented cells because all batteries need to be vented to prevent gas build up and exploding during charging. Will not immediately leak if overturned but will over time. They are designed in such a way as to recover a large portion of the electrolyte that is normally lost through gassing of a normal wet cell. Even so, these batteries will loose electrolyte over time, causing premature failure due to overcharging.

HydroCaps and Water Mizers

These two after market devices fit in place of ordinary wet cell caps and are designed to reduce electrolyte loss from recharging by recapturing the escaping fluid. Both are widely reported to be quite effective. HydroCaps are about twice as effective as Water Mizers as the HydroCaps recombine escaping hydrogen and oxygen into water and cost twice as much (about 6.50 each) as Water Mizers. Good for boat owners who want to maintain their batteries carefully. Particularly good for very heavy battery use and deeper discharges. Recommended for large, non maintenance free batteries.

Sealed or Not Sealed? Most deep cycle batteries are not sealed, or may have removable recovery caps as described above. This is because deep cycle types will last a long time in which some electrolyte loss is inevitable and you want to be able to add water as needed. If you care about battery maintenance, unsealed or types with recovery caps are the best choice.

Battery Size

Unfortunately, battery manufacturers play a lot of games with battery sizes and ratings, making it very difficult for us to identify battery power. This is because of two factors that can be manipulated for marketing purposes. The most important things to know a bout a battery (other than voltage) is how much power and for how long. As discussed above, there are also legitimate reasons why manufacturers will favor one aspect over another, as in the need for high cranking power or longer discharge rates.

The physical dimensions of a battery are loosely relative to it's power. A battery with more or larger plates in it naturally has to be physically larger, and so does a battery with thicker plates like the deep cycle battery. This is why automotive batteries can be rather small, and yet have high CCA ratings but very low reserve power.

Group Size This is a rating promulgated by Battery Council International that defines nothing more than the *physical, external size of the battery.* It's purpose is to determine what size battery will fit in a given space; it has nothing to do with power rating.

Battery Types

Battery manufacturers often refer to their range of products rather inappropriately as "types". One manufacturer defines types as lead-acid versus NiCad, while another refers to 1D, 3D, 4D and 8D, or group number batteries as sizes. As near as I have been able to determine, 4D and 8D were model names of the Surette Battery Company that have since fallen into generic usage. The 4D is a 150 A.H. battery and the 8D, around 250 A.H. The 4D and 8D sizes are commonly referred to as boat sizes. Alternatively, there are the BCI types which are group sizes that have nothing to do with ratings, only physical dimensions.

Battery Ratings

Amp-Hour battery rating: AH is a common battery rating for batteries. Amp-hour rating of battery capacity is calculated by multiplying the current (in amperes) by time (in hours) that the current is drawn. Variations of the amp-hour battery rating is the most used rating. It most commonly signifies a deep cycle, marine or industrial battery.

Example: A battery which delivers 2 amperes for 20 hours would have a 40 amp-hour battery rating (2 x 20= 40). This is known as the 20-hour rating versus other ratings based on times such as 5, 8 and 100 hours, but also at different amperage rates. Such ratings are given based on what is considered most useful for the intended application. A battery intended to supply low amperage for long periods, for example, would use the 100 hour method, whereas a 5 hour rating would likely be for a high amperage rate. The 20 hour method is most common.

Cold Cranking Amperage rating: CCA is the discharge load in amps which a battery can sustain for 30 seconds at 0 degrees F. and not fall below 1.2 volts per cell (7.2V on 12V battery). This battery rating measures a burst of energy that a car needs to start on a cold morning. This rating is used mainly for rating batteries for engine starting and tells you that you are looking at a starting battery. Example: the battery in my car is rated at 580 CCA. What does that mean to you and me? Well, probably nothing for it's meaning is relative to the ratings in other batteries. It says nothing other than an indication of starting power unless one is up to doing some serious math.

Reserve Capacity rating: RC is the number of minutes a new, fully charged battery at 80 degrees F will sustain a discharge load of 25 amps to a cut-off voltage of 1.75 volts per cell (10.5V on 12V battery). This battery rating measures more of a continuous load on the battery and is a much better indicator of how it will operate bilge pumps. An RC number given in the specification indicates that it is more than just a cranking battery and probably a hybrid starting battery. ***This is a very useful rating for a boater.***

Reserve capacity is directly, though not completely, related to battery plate size and quality. As a general rule, cranking batteries have little reserve capacity after cranking operation unless they have thicker plates. If they have thicker plates, it will have a lower CCA rating.

MCA Marine Cranking Amps is a proprietary rating that is the same as CCA. It's an indicator that the battery is most likely an ordinary automotive cranking battery sold as suitable for boats.

Warm temperature affects lead-acid batteries positively, but cold temps negatively. These batteries in hot engine rooms are not negatively affected as higher temperatures actually increase voltage.

Ratings By Month and Warranties Increasingly consumer batteries are being sold with month/life ratings, such as 24, 48, 60, etc. As with all advertising, the words are better than the reality, particularly when you don't read the fine print. The bold print giveth and the fine print taketh away. Virtually all of the batteries that I have investigated that use month/life advertising, do not make any warranty that the battery (s) will last that long. Only the "60 month" moniker merely suggests that.

Virtually all "consumer" or mass market batteries have "pro rata" warranties, and that only for "defects in materials or workmanship. The vast majority of marine batteries investigated have 24-30 month warranties on a pro rata basis. That means that if the battery lasts 18 months on a 24 month warranty, you'll have to pay 75% of the cost of a new one while the manufacturer chips in 25%, assuming there is a defect and you did not fail to keep it properly charged.

The following warranty examples from a mass market battery (marine) labeled as 60 month:

ABC Battery Company warrants only to the original purchaser that: 1) this battery is free of defects in material and workmanship for the number of months indicated on the label, and 2) prior to installation or use, the state of charge of this battery has been maintained at a level equal to or greater than the minimum level considered necessary under industry standards for batteries to perform effectively upon their use or installation. If adjustment is necessary due to a defect in material or workmanship, or state of charge below minimum industry standards prior to installation or use, and the battery is NOT MERELY DISCHARGED after installation or use, then upon return of the battery to an authorized dealer: b) Within twelve (12) months from the date of original purchase, all marine batteries of the following types: HD24-DP, 24M-HD,

24M-RD, 24M-XHD, SRM-24, SRM-27, SRM-27B, SRM-29, will be replaced free of charge (except for taxes, where applicable).

The following is a warranty from Rolls-Surette:

Failure within 24 months from the date placed in service yields FREE REPLACEMENT, not including freight charges from the factory to the applicable destination. After the first 24 months of service, defective batteries will be adjusted for a period of up to 60 months prorated from the date first in service at prices in effect at time of adjustment.

Reading the warranty will often reveal the quality of the battery. A broader warranty usually means a better quality unit.

Typical Service Life Under Deep Cycle Use*

Cranking battery 12-18 months
Marine 1-4 years
Gel Cell 2-5 years (excluding Florida)
Golf Cart 2-6 years
Deep Cycle 4-6 years
Surette Deep Cycle 6+ years**

* Assumes proper installation and maintenance, and a properly calibrated charger. Based in part on personal observation from surveys as well as opinions of other experts. The range of time is dependent on frequency and degree of use.

** Surette batteries are often found in large yachts where short battery life is rarely a problem, in part due to high grade chargers and frequent maintenance.

My Recommendations for Boat Batteries

Outboard boats can get away with using automotive cranking batteries so long as there is no heavy power demand equipment) this does not include navigation equipment like radios, GPS, fish finder, etc., as these use little power. Equipment such as live bait well pumps, trolling motors, spotlights, electric down riggers, video chart recorders and so on demand deep-cycle batteries. However, to avoid annual battery replacement, deep cycle batteries will perform best when charging is completely reliant on engine alternators since cranking batteries do not tolerate deep discharges well. Further, if you're going offshore where there may be high demand on bilge pumps, BEWARE that cheap automotive batteries aren't going to run your pumps for very long, particularly after engine failure. ***Offshore operators should use higher capacity deep-cycle batteries.***

Because of the high power demands on batteries in cruisers while engines aren't running or being charged by chargers, cranking batteries are a poor choice unless a boat has no appreciable other DC equipment. Boats with DC refrigerators, radar, anchor windlasses and other heavy power demands are best served by true deep cycle batteries. They are the primary reason why so many small boat owners have to replace batteries so often. MY advice is to avoid batteries labeled "auto-marine."

Sport fishermen typically have very high power demands so that only deep cycle batteries can be expected to perform well.

The question of whether you should buy deep-cycle versus marine batteries is fairly well answered by the increased service life of true deep cycle batteries versus those labeled "marine". Larger size deep-cycle batteries have no problem handling engine starting and go on providing reserve power for other things even without charging. Because boat batteries are subject to a lot of abuse, spending the money for higher quality deep-cycle batteries is usually well worth the extra cost.

Most dedicated battery resellers (those that serve business, industry and marine) typically quote prices at an installed rate. That means that they will deliver the batteries to your boat and install them and insure that they are installed properly. If you've ever tried to move batteries in and out of your engine room, you know that this is no easy task. 8D batteries weigh up to 190 lbs. Thus, the prices when quoted may at first seem very high, but are a lot less so when you realize that this includes installation and disposal of your old batteries. (We are now required to pay an environmental impact fee for battery disposal, which pretty much cancels out the salvage value that we used to get for old batteries.)

Battery Charging

Charging is a complicated issue that I'm not going to get into here beyond saying that battery charging becomes a problem when engines aren't operated long enough to complete a full charge, such as infrequent use and frequent starting and stopping. This happens as a result of short runs, as in fishing. For boats that are always on shore power systems when not running, this isn't a problem. Outboard boat owners most often suffer from battery failure due to incomplete charging. Achieving a complete charge will take several hours at least, so when you're operating for shorter periods, it is likely batteries aren't being fully charged.

Incomplete charges have a cumulative effect; that is, after incomplete charging, the battery is partly depleted and this leads to yet further depletion and longer charging times. It may only take two incomplete charging cycles for a battery to ultimately fail to start an engine, or even become damaged. The reason car batteries fail so frequently is due to short hops that result in cumulative incomplete recharging.

There is really no such thing as quick charging when talking about completing a full charge. A quick charge may bring a battery up sufficient charge (75%) to start an engine, but full charging takes much longer at lower amperage to complete the final 25%.

Battery Testing

The problem with any simple method of testing batteries is that it is only good for proving the negative. That is, you can prove that a battery has low power or is bad, but without a load tester you can't prove the overall condition. If you have wet cell batteries, using the hygrometer is useful under controlled conditions, like before charging when the electrolyte is well mixed. After charging the electrolyte tends to concentrate near the top and give false readings. But with sealed batteries all you can do is test the voltage which will only tell you the present state of charge, not the likely remaining useful life.

The voltage on a fully charged battery should be about 12.7-12.8 volts. If it's higher, the charger is on. Batteries will usually fail to start an engine at 12 volts or less. This is dependent on the age of the battery. A new, but depleted battery may only fail to start at a voltage as low as 11.5 volts.

Be wary of electric panel meters; they are often very inaccurate. Use a multi meter to test the batteries and then reset the panel meters if they are adjustable. Also, be aware that with the engines running, the helm voltmeters are reading through the alternator and are showing the charge rate, not battery state. Read these meters without starting the engines.