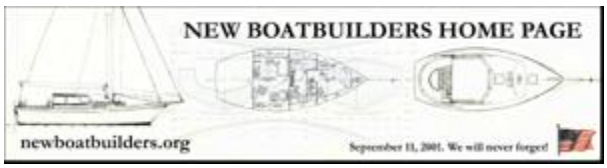

Batteries and Chargers:

I keep seeing this question on several of the forums that I participate in. Basically it is; what battery charger should I use? To answer this question you first need to ask what kind of batteries do you have, and how many?

So first let's cover the basics on batteries. I am only going to discuss 12V DC. There are other systems such as 48V and systems that use both 12V DC and 120V AC. But to simplify this I will stick to 12V, since most boats have 12V DC systems. The simplest have a single 12V battery for starting the engine, running instruments, lights, and a few electronic gadgets such as GPS or depth sounders.

The next step up from this is a boat that has a starting battery and then a second battery for running electrical equipment; in particular bass boats usually have a separate battery to power the trolling motor.

Then there are larger boats with all kinds of electronic equipment, beyond the basic stuff such as GPS or depth sounders. These boats can be equipped with computers, TVs, VCR's, sound systems, microwave ovens, radars, and so on. These boats generally have a starting battery for each engine and a bank of batteries running all the other equipment. They may have a generator, a charger, an inverter (DC to AC), and converter (AC to DC). They will also have an AC electrical system for AC equipment.

So what types of batteries are used? There are three types of 12V batteries that are commonly used; wet cell, AGM, and Gel Cell.

The wet cell is the lead, zinc, acid battery that we all are familiar with because we have them in our car. It is called a wet cell because it contains a liquid, a dilute acid, that acts as an electrolyte to transfer electrons to the plates. As the battery is discharged and recharged the liquid level goes down, and occasionally distilled water has to be added to keep the liquid at the correct level. When charging it is best to open the caps on the top of each cell so that any pressure build up is relieved. These batteries give off hydrogen gas while charging so they must be in a well ventilated place.

AGM stands for Absorbed Glass Mat. This battery has lead and zinc plates, like any battery, but has glass mat material between the plates that absorbs and holds the liquid electrolyte. The other difference is that this is a "sealed" battery. They are also called Sealed Valve Regulated (SVR) batteries. In theory you never have to add any liquid to the battery. In fact, there is no way to add liquid. But a common misconception is that these batteries do not out gas, that is, give off hydrogen gas while charging. So people install them in places that aren't ventilated. This is a mistake. Under normal charging

conditions they will not out gas, but they do have a small valve in the top of each cell that, if the battery overheats while charging, will open and release hydrogen. These batteries are very sensitive to charging voltage and temperature. Over charging will result in overheating, out gassing, and a significant shortening of the life of the battery because it dries out the mat.

Gel Cell batteries, like AGM are SVR batteries. However, the electrolyte is not a liquid; it is a jelly like substance. These batteries are sealed and do not require adding liquid after many discharges and recharges. However, like the AGM batteries, they are sensitive to charging voltage and, if over charged and over heated, will out gas and lose some of their life.

In addition to these three types, batteries are also classified as starting, deep cycle, and combination starting/deep cycle. Starting batteries are used primarily for starting the engine. This requires a battery that can release a large current (amperes, or amps) very rapidly. Starters require a lot of amperage because of the heavy load trying to turn over an engine. To achieve this, starting batteries are built with many thin plates, that are rapidly discharged and recharged. However, this also means that the voltage from the batteries will quickly drop to a level that is too low, causing overheating of the starter and if also used to power electronic equipment, problems with the operation of the equipment.

Deep Cycle batteries on the other hand, are designed to release energy slower. They have much thicker plates. They do not release as high an amperage as a starting battery but will maintain the voltage level for a much longer period, so they are use on boats, and other recreational vehicles, as "house" batteries to run all of the electronic equipment and appliances. They also require charging at a slower rate than starter batteries.

Then there are combination batteries that have both thick and thin plates and are used for both functions. These are often sold as "marine" batteries.

All batteries are also rated by cold cranking performance, also known as cold cranking amps or CCA. This is a measure of how many amps the battery can deliver for 30 seconds and maintain the voltage at 12V. Basically the higher the CCA rating the longer the battery will maintain its voltage.

So how does this affect the charger?

The typically automotive charger is what is known as bulk rate. It pumps current into the battery at a constant rate. If it is rated at ten amps then it constantly charges at ten amps. This is not really good for a battery because you need to keep track of what is going on and not allow the battery to overcharge. But they can be used to give the battery a quick boost. They should not be used for long term charging and maintenance.

Most chargers sold today are "smart" chargers. They have a small computer built in that senses the charge state of the battery and as the battery reaches full charge, reduces the

amperage to avoid over charging, over heating and destroying the battery. When the battery reaches full charge the charger stops charging. They are often called three stage chargers because they use three stages to charge; bulk, absorption and float. Bulk is used when the battery is deeply discharged and can accept recharge at the highest rate. (I am not going to discuss charge acceptance rates here, but that is what determines how much charge the battery can accept per unit of time, and how fast the battery recharges) During absorption voltage stays constant and the current slowly tapers off. Float is used after the battery has reached full charge to maintain the battery. This used to be called trickle charge. The more sophisticated of these can tell you the state of the battery, if you have shorted plates (plates touching each other), or if the battery is no longer any good. Some also have a temperature sensor that you can hook to the battery. This type is a must when charging AGM or Gel Cell batteries so that they do not overheat and ruin the battery.

When charging Gel Cell and AGM batteries the charger also need to be "voltage regulated", that is, you can set the voltage range so that it does not rise too high or go too low. The voltage range of the battery varies from brand to brand and battery type. Charging at too high a voltage can shorten the life of the battery. Many of the chargers set the voltage automatically. It is always best to use the charger that is recommended by the manufacturer.

How about charging amps? How many charging amps should you have, 10, 20, 40? Well, the larger the CCA of the battery then the larger the amperage of the charger should be. Also, it depends on how many batteries you have. If you are charging a single battery you do not need as many amps as if you are charging a bank of two or three batteries. A 10 amp or 20 amp charger is adequate to recharge a single starting battery, but a 40 amp charger is much better for charging a pair of deep cycle batteries.

Some battery manufacturers use a rule of thumb to determine the charging amperage for a battery. For wet cells this is CCA/8, or the Cold Cranking Amps divided by 8. So if you have a 220 CCA battery this would be 26 amps. For AGM batteries it is CCA/20, but check the battery owner's manual. If you had two batteries in parallel, it would be 2 X CCA/20

However, for both Gel Cell and AGM batteries it is critical that the charger be voltage regulated and temperature sensing, to get the maximum life out of the battery.

So what about Lithium batteries? Lithium battery technology for the marine environment (as of June 2014) is still in the stage of development. There are boats, mostly large expensive boats, that use Lithium batteries. The batteries themselves are extremely expensive. But you cannot think of Lithium batteries without thinking "system". These systems are designed specifically for these boats. You cannot just drop a Lithium battery into your boat in place of Lead-Acid, AGM or Gel batteries. The charging and management systems for these batteries need to be designed from the ground up to be safe.

There are various types of Lithium batteries based on their chemical composition. Lithium batteries have a tendency to overheat and go into thermal runaway, causing a fire. The best Lithium batteries to use on boats are LiFePO4 (Lithium Iron Phosphate) batteries. They have the least tendency among Lithium batteries to go into thermal runaway. Also, Lithium batteries must have a Battery Management System (BMS) either built into the battery or attached to it, that controls the voltage and all the other functions of the battery. The charging system must also be designed specifically for Lithium batteries.

Lithium batteries have many advantages. They are much lighter and deliver more power per pound than conventional batteries. When installed correctly with a BMS and a charging system designed for Lithium, they live three to four times as long as conventional batteries. But, to be safe a Lithium installation needs to be correctly designed and installed.

So I would not advise a beginning boat builder to even consider Lithium batteries without advice and assistance from an expert on designing Lithium power systems as part of your boat design team.

Here are some good links on batteries.
Wind & Sun http://www.windsun.com/Batteries/Battery_FAQ.htm#Battery%20Charging
AGM Battery Tech Manual
http://www.zimmermanmarine.com/docs/AGM%2520article.pdf
Gel Cell Battery Tech Manual http://www.mkbattery.com/pdf/technical_manual.pdf
Battery References Link List (everything about batteries)
http://www.uuhome.de/william.darden/batlinks2.htm
Lithium Batteries:
Emergent Technologies; Evolving Hazards
http://www.boatus.com/seaworthy/magazine/2012/january/hazards.asp
MasterVolt: Lithium Batteries:
http://www.mastervolt.com/marine/products/li-ion/
Power And MotorYacht: The Low Down on Lithium Batteries:
http://www.powerandmotoryacht.com/refit-and-upgrade/lowdown-lithium-batteries