Current Monitoring

To interpret an Amphour-meter

"The battery gauge", that's what many call the little instrument. Being able to check how much power you have left is a good thought. But the amphour-meter needs to be calibrated and may show so much more than just this. Correctly interpreted, the amphour-meter quickly becomes your most important instrument to monitor and improve your charging system.

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The service-batteries in a boat are working hard, especially when one is out cruising and living onboard with long periods between marina berths. Compared with their engine start colleagues, they must withstand regular deep discharging, something starter batteries are especially bad at. A starter battery is made for working during just a few seconds each time, after which it becomes re-charged again. To be able to free up as much current as possible during this short period of time, the lead plates inside the starter battery are many and thin to allow for maximum surface for the heavy chemical reaction. A service battery, on the other hand, is designed for quite the opposite. Starter batteries inappropriately used for service may last as short as a couple of months onboard a serious cruising boat.

The fact that many sailors seem to do all right with starter batteries for service, nevertheless, can only result from frequent access to shore power, frequent motoring or thanks to the fact that discharging is made to no more than 20-30% of the battery's capacity. If you are among these, you may stop reading here. This article is for the sailor who likes to anchor. Learn to read amps, volts and amphours on your amphour-meter, and you will soon be able to build an effective charging system. At the same time, you can react immediately, should something not be as usual.

A true deep-cycle battery also found in numerous golf-carts.

Fruther to current, voltage and amphours, the Ah-meter can also show the battery status in percent.

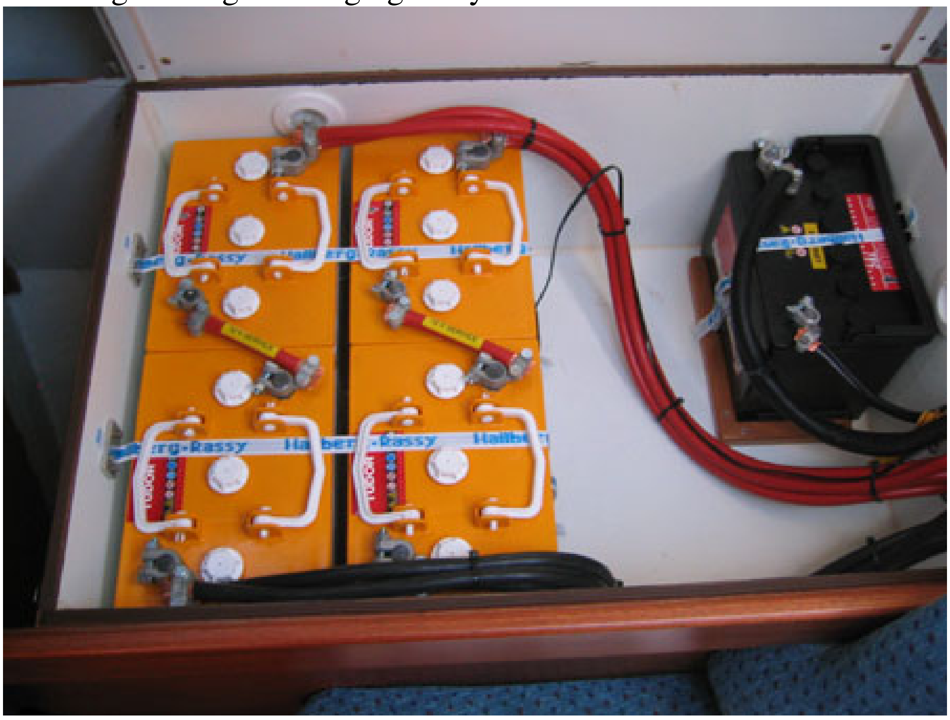
Lets take the easy part first: Discharging. Here, you read the current, which is drained from the battery (measured in amps, A). Is everything switched off, it should read 0A. If not, you might have a leakage, like a lamp that is left on. Switching on applications one by one, the current increases while you may observe how much the individual equipment actually is consuming. So far, everything should be as clear as an anchorage in the Caribbean.

At what stage are the batteries then getting "empty"? Well, that is when a certain amount of current (A) has been consumed during a certain number of hours (h). Batteries are either drained by much current during few hours or little current during a longer period. The "quantity of power" is calculated as amps times hours = Ah.

- For the technically interested I can mention that this does not quite give the same result. The battery has a higher capacity (Ah) if you discharge with little current during a longer period, than the other way around. USA and Europe have different standards to measure this and that's why an American 100 Ah battery has less capacity than its European equivalent.

The ingenious amphour-meter is automatically integrating the current over time, meaning that it is adding up the used current during each specific time period, presenting it in Ah or percentage of the battery's total capacity. If you, for instance, have used 30Ah out of a 100Ah battery, you have only 70% left. Voilà! Still not too difficult, right?!

How about the voltage then? During discharging, you should disregard from the voltage, since it is varying heavily depending on the load and hence is misleading. Many boats unfortunately only have a volt-meter so their owners try to get an indication of the battery status from its reading. If you wish to use a volt-meter, you need to switch off everything onboard first, letting the batteries rest for at least half an hour and then very carefully measure the voltage, something an analogue instrument is not capable in doing. So: Forget the voltage during discharging is my advice.



A prefessional battery installation: starter battery in black (to the right) and deep-cycle batteries in yellow (to the left). Foto: Marcus Åkesson

How many amphours (Ah) can you expect from your battery? It's definitely not close to the figure shown on its casing, at least. Generally, the deeper you drain your battery, the shorter its life. Ordinary starting batteries are especially incapable in deep discharging (please observe that many so called "marine" batteries are just starting batteries in camouflage). Unfortunately, there is no clear distinction between these two types. Real service batteries are often called "traction batteries" and are of deep-cycle type. To allow for many deep cycles, the lead plates are extremely thick and sometimes rolled up into cylinders, placed in a robust housing. Ask which batteries are used for electrical trucks or golf-carts and you will be much closer to a good service battery for your boat than found in many chandleries.

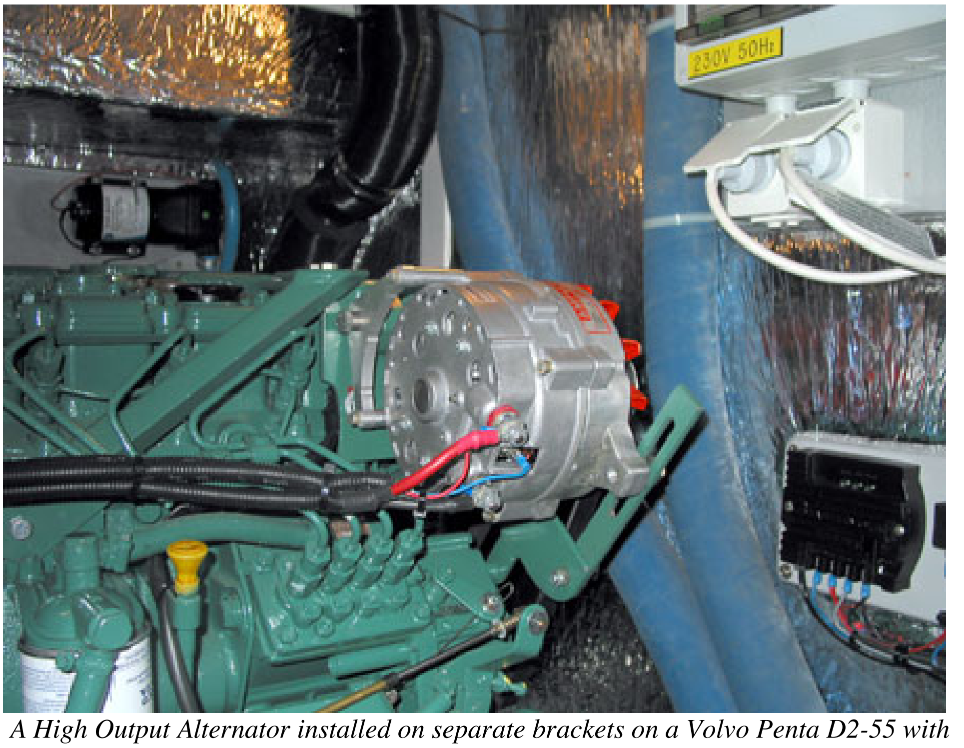
Even with a good battery in your boat, I would not recommend to discharge it to more than 50%. I think this is a good compromise between benefit and lifetime. Please observe that an

AGM-battery generally tolerates even less than open wet lead-acid batteries.

To understand the charging process, you need to know your charger. Your amphour-meter gives valuable information for this by showing voltage (V), current (A) and amphours (Ah). These, you need to monitor during the charging process.

Many simple chargers are of a type called "constant power". When the voltage increases during the charging process, the current decreases at the same time, resulting in a very inefficient charging process, which means unnecessarily many engine hours. Check this next time you run your engine! Does the current (A) decrease linearly over time? If so, you should consider installing an external intelligent regulator, preferably together with a High Output Alternator (HOA).

The HOA makes sure that a maximum of current is delivered to the batteries and the regulator decides in what rate, allowing for shortest possible charging time without damaging the batteries. Unfortunately, not all engine manufacturers supply their engines with an HOA-kit with an external regulator. Yanmar does, for instance, but with Volvo-Penta you have to find an external supplier for second brackets, HOA and regulator (e.g. by Electromarine in Norway).



A High Output Alternator installed on separate brackets on a Volvo Penta D2-55 with external regulator on the wall after 1500 hours.

What is the difference between the HOA and an ordinary alternator? A standard-alternator can only generate the nominal current under very favourable conditions: it must be cold and run with maximum rpm's. A small alternator mounted onto the hot engine in a cramped engine room rises in temperature very quickly, of course, both due its surrounding, but also due to its inner friction. Have you checked your alternator how much power it generates after five or ten minutes? Install an amphour-meter and I am sure you will get disappointed! Many alternators deliver no more than maybe 50% of its nominal rating. A true High Output Alternator, preferably in a so called "large case" with cooling fan, is able to deliver maximum current already at very low rpm's and even while hot. Remember not to paint your alternator, especially not in any dark colour. Best is to leave the alternator unpainted allowing it to convey and radiate the heat from its housing.

The electronic external regulator, on the other hand, makes sure that maximum of current is lead to the batteries without damaging them. Charging is often done in three steps: “Bulk”, “Absorption” and “Float”.

The "brain": The external regulator

During “Bulk”, every possible last bit of power is stuffed into the batteries. On your amphour-meter, you will see how the current (A) is kept at its maximum during the entire “Bulk”-phase, thanks to the intelligent external regulator, despite the fact that voltage is increasing.

The Batteries are charged with 155A!

How much may you charge your batteries with, by the way? Open lead-acid batteries may be charged with 30% of its capacity (e.g. you may charge with 150A, if you have a battery bank of 500 Ah). GEL and AGM-batteries may take more: These can be charged with as much as 50% of its capacity (you may, in other words, charge a battery bank of 500 Ah with 250 A).

And for how long may you continue to charge your batteries with so much current? Well, either, until the batteries get too hot (and that’s why most regulators have a temperature sensor on the batteries), or until a certain pre-programmed voltage has been reached. When the voltage on the batteries (not on the alternator!) has reached the chosen value, the batteries cry out: “Thanks! That’s enough! Please take it easy, man!”. On your amphour-meter you can exactly follow when this is the case, namely around 14.4 – 14.8V . But remember never to set the value for GEL and AGM-batteries higher than to 14.1 – 14.4V 2.

- The voltage to be set on your regulator is depends on the battery manufacturer’s recommendations as well as temperature. Generally, in a 12V system, decrease the voltage by 0.3V for each increase of 10°C or by 0.17V for each 10 F.

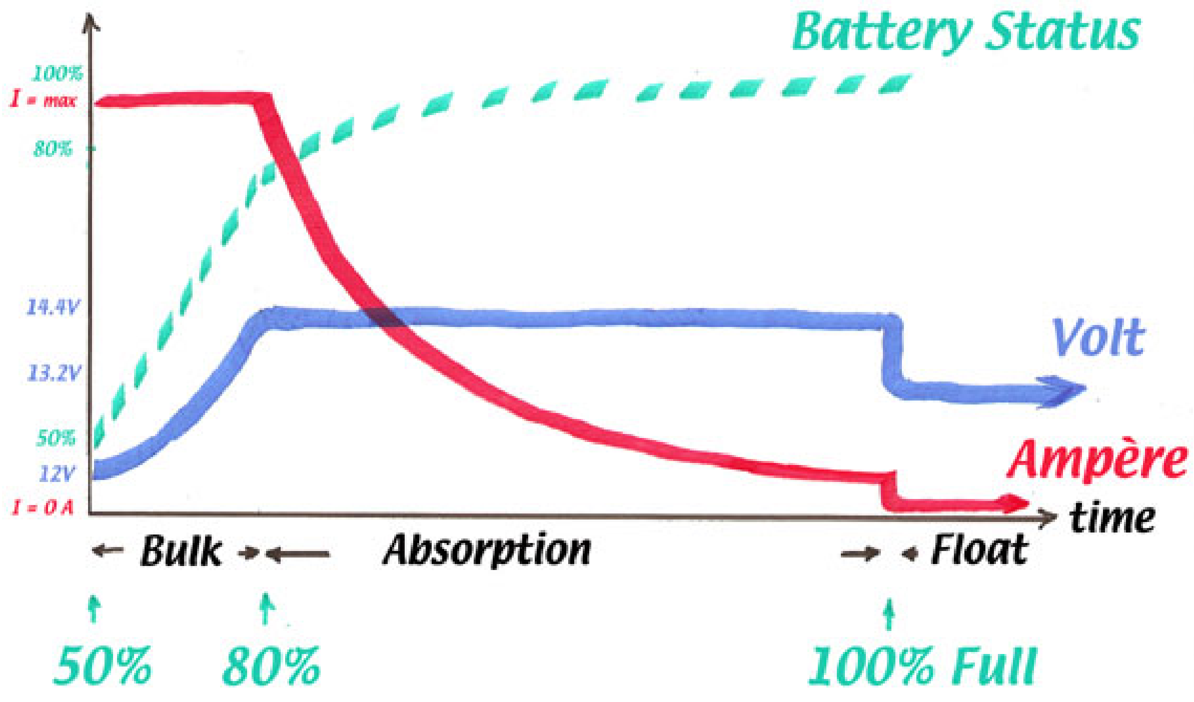
When the set voltage has been reached, the regulator changes over to the next phase, called “Absorption”. The batteries have by now been charged to approximately 80% of its capacity.

Do you remember our scenario? We discharged down to 50% and have now charged efficiently to approximately 80%. In other words, we have merely been able to use 30% of the battery’s capacity! Many cruisers and liveaboards stop charging now, after having run their engine for maybe 40 minutes. Without an amphour-meter, it would be difficult to know when charging starts to become less efficient. To charge the batteries up to 100% is just not practical on a cruising boat at anchor, not even with a diesel generator.

To stop charging at this point is certainly not good for the batteries, but that is unfortunately the fact for a poor deep-cycle battery that was unfortunate enough to to end up onboard a cruising boat. What a destiny! Since one only uses 30% of the battery's capacity, you might understand why blue-water sailors often have large battery banks and invest in high quality deep-cycle batteries, which are much better to withstand this horrifying treatment.

To be nice to your batteries, you should give them a treat from time to time: at least once a month they should be allowed to become fully charged to 100% (thank goodness for shore power!).

So, let's be just as nice to our batteries this time, as the manufacturers request from us. Instead of breaking off after the "Bulk-"phase, lets continue into the "Absorption"-phase. The regulator is now ensuring that the voltage does not rise any longer and is kept at the pre-set value. The current, however, which was stable at its maximum under "Bulk", decreases now rapidly.



The higher the set voltage, the faster the charging is being performed during "Absorption". Onboard our Hallberg-Rassy 40 Regina, we are charging with 14.8V at 25°C (80 F) during this phase. Higher Voltage is actually doing good to wet lead-acid batteries, since the rising hydrogen bubbles during gazing are mixing the acid. Just don't forget to check the water regularly and top up whenever necessary.

- The only disadvantage to charge with a somewhat higher voltage is that the lifespan of light bulbs decreases. Halogen bulbs have less problems with this, by the way. Before setting your regulator, always check with the battery manufacturer and also check what the maximum allowed voltage for your equipment is.

AGM or GEL-batteries may never gas and hence, as said above, never be charged above

14.1 – 14.4V. Charging this type of battery is somewhat slower during “Absorption”, thus.

The “Absorption”-phase is now to continue until the batteries are considered full. This may take up to 12 hours (maybe you have some understanding for the poor cruiser at anchor, who cuts off at 80%?). After “Absorption” the regulator goes over to “Float” (typically to 13.2V).

Some regulators switch from “Absorption” to “Float” after a pre-set time. Other regulators are integrated with the amphour-meter and consider the batteries as “full”, as soon as the current has gone below 2% of the capacity and may even automatically zero themselves at the same time, putting them back to “100% full”. But even if you don’t have such an integrated system, you can do it manually: If the charging current, for instance, goes below 10A and you have a 500Ah battery bank (i.e. 2% of the capacity) you can consider the batteries as full, irrespectively if your instrument shows “100%” or not.

How come would the Ah not necessarily read 100% when they’re full!? Well, an amphour-meter needs to be calibrated, you see, because the batteries have an efficiency coefficient. If you discharge your batteries with, say 95Ah, you might need 100Ah or more to charge them again. This coefficient needs to be set on your amphour-meter, otherwise it will show incorrect values after a few cycles only. Here, you need to do some trial-and-error, since the efficiency coefficient varies with the age of your batteries (the older the less efficient) and the charging current (the higher the current, the less efficient). You must hence find an approximation for your own boat so that the amphour-meter goes over to 100% exactly when the batteries get full. I suggest you start with a coefficient of 95% to start with, and rather choose a lower value than a higher, so you don’t fool yourself and believe the batteries are fuller than they actually are. If you are really sure that your batteries are full (e.g. after a day on shore power), you can zero your amphour-meter to 100% manually.

After a couple of charging cycles one gets a feel for how the batteries are being charged and can set the regulator accordingly. The usual values to programme your regulator with are the voltage at which the regulator should switch from “Bulk” to “Absorption”, the time it should stay in “Absorption” and the voltage it should provide under “Float”, so that you obtain a balanced system and the amphour-meter shows close to 0A.

I believe you agree with me that it is very comfortable to just sail from marina to marina, from one shore connections to the other and not having to bother about all this stuff. Life is so easy with power coming out of the plug! But freedom is found beyond shore power, at an anchorage not far from home or by sailing south into the sunset. With some basic knowledge about your amphour-meter, monitoring your batteries, your alternator and regulator, possibly also your solar panels, wind- or water-generators, you can stay out from civilisation for a long time and still be independent on power production.

That’s not too bad!

Regina, self-sufficient with power at anchor in Barbuda, Caribbean