Battery Handbook

By: RON SMITH

Information compiled from the Battery Charger Handbook and the Battery Handbook written by Alvin G. Graham, Chief Engineer, Ratelco Electronics Inc.

Introduction

The purpose of this paper is to briefly acquaint the reader with the different kinds of batteries used in marine service and with the typical charging requirements of each. All noted voltages are shown to provide the reader "rules of thumb". Consult the manufacturer of your batteries for the specific charging and maintenance voltages. General information is offered on the effects of voltage on recharging rates, battery grid corrosion, and battery life in general. The reader will note the different objectives in battery charging, e.g. cell equalization, rapid charging, and forming new batteries, are accomplished at different charging voltages. Multi-bank charging and electromagnetic interference (EMI) are also briefly discussed. Specific information on the Quality Marine VM and ***VMI*** marine battery chargers is shown to inform the reader on that product's ability to meet all the objectives of marine battery charging.

Summary of the Quality Marine VM and *VMI* Battery Charger

Three important design features make the Quality Marine VM battery charger the best value on the marine battery charger market today.

First, the Quality Marine charger's **constant voltage output** provides current necessary for meeting load requirements, while maintaining the battery at float voltage. Constant voltage charging prevents battery cycling and provides for years of extended battery life. This means hundreds of dollars worth of savings down the road.

Second, charge voltage is **manually adjustable** on all Quality Marine chargers. This allows the user to adjust the Quality Marine charger to meet any charging objective e.g. rapid charging, periodic cell equalization, forming new batteries, and maintaining any type of battery at its proper float voltage.

Third, Quality Marine chargers **tolerate extreme input variations**, in line voltage or generator frequency, and still do their job. Input variations are a fact of marine life and the ability to tolerate them means protection of the customer's investment in both charger and batteries.

In addition, the **quality** and care that goes into the manufacturing of Quality Marine chargers ensures that the Quality Marine customer will get decades of reliable performance for his initial investment dollars.

Lead Acid Batteries

Two types of lead acid batteries are found in marine service, lead calcium and more commonly, lead antimony. In both, the plates are of (1) grid and (2) paste. The paste, the active material that holds the charge, is made up of lead dust, sulfuric acid, and possibly some kind of fiber to increase strength and reduce mud formation. The negative plates may have other substances to improve discharge performance or prevent capacity loss during repeat cycling. The density and porosity of the paste, along with the physical dimension of the plate, determine the capacity loss during repeat cycling.

The density and porosity of the paste, along with physical dimensions of the plate, determine the capacity and discharge rate of the plate. If high discharge rates are desired, as would be with starting batteries, the plate is made thin and the paste porous. More plates are used in the battery. These batteries are generally of the lead calcium design.

In deep cycle batteries, or when lots of cycle life is desired, plates are made thicker and the paste more dense. These batteries are generally of the lead antimony design.

Selecting Recharge Voltage

When selecting recharge voltage, three things must be considered: (1) speed of recharge, (2) length of applied voltage, and (3) load. If a Quality Marine charger capable of supporting average loads is selected, battery management becomes easier. If not, understanding the following will allow the Quality Marine owner to properly use the voltage adjuster to accomplish all the objectives of battery charging.

Battery life is maximized when the battery is maintained at what is called float voltage. Simply put, it is a voltage above that point where a battery begins to accept a charge and below the point where it begins to gas. Above float voltage, several things begin to happen. First, the rate of recharge accelerates and battery cell voltages work toward equalization. Beyond that, most of what happens is detrimental to battery life. For example, in lead antimony batteries, float current doubles with every .05 volt per cell (vpc) that a battery is increased over float voltage (float current is that current which flows in a battery, due to losses in a fully charged cell, with a given potential on the plates). As float current accelerates, so does grid corrosion, preventing charge storage and reducing battery life. Moreover, when lead calcium batteries are maintained at overly high voltages, or repeatedly cycled, they can fail prematurely because associated heat and stress cause the plates to grow.

Battery gassing and water loss accelerate rapidly once float voltage is exceeded, gasses can accumulate and present an explosive situation. If plates become exposed due to severe water loss, they sulfate and capacity is permanently lost. Therefore, **the duration of time a battery is charged above float voltage must remain short, 24 to 72 hours.**

Cell Equalization, Rapid Charging, and Forming Batteries

Charging a battery at a voltage higher than its float voltage should only be done for one of three reasons, either to equalize cell voltages, rapid charge, or form new batteries. Charging new batteries at an equalize voltage for 48 to 72 hours serves to establish a firm voltage and polarity imprint. **Always ventilate the compartment before equalizing.**

In cycle service, a number of things, such as impurities in the electrolyte or variations in electrolyte level across cells, can result in a situation where cells charge unequally. If allowed to continue, cell failure may occur, particularly in antimony batteries. This can be prevented by charging the battery at a higher voltage (every 2 months) for 8 to 24 hours. The same voltage settings used for cell equalization can be used for rapid charging. These voltage settings for different batteries are described below.

Rapid charging may be desired when a load period exceeds the chargers output and cell voltages drop below the "start to charge" voltages shown below. No charging takes place until the cell voltage is restored to that point. By elevating recharge voltage, the time it takes to restore a battery to 95% recharged state is dramatically reduced.

Recharging a battery at float voltage is a slow process. For example, a 30% discharged 100 amp-hour, 8 hr. rated battery, at a float setting of 2.15 vpc will take 55 hours to become 95% recharged. That same battery will become 95% recharged in 5 hours if the recharge voltage is raised to 2.25 vpc, and in 4 hours if raised to 2.33 vpc. If the Quality Marine charger is adjusted to a higher voltage to provide more rapid charging, little detrimental effect will occur if the charger is readjusted to float voltage in less than 72 hours. Check battery water before and after equalizing or rapid charging.

During periods of increased cycle activity, where average load often exceeds the charge output, the Quality Marine charger can be set to a compromise voltage to speed up recovery.

This "high float" (2.25 vpc) poses less risk to the battery than a rapid charge setting would if forgotten. When load seldom exceeds the chargers current rating, keep the charger at a proper float voltage. Then, only occasional inspection and equalization is necessary to produce long battery life.

Measuring Specific Gravity or Voltage for Full Charge

The specific gravity (SG) reading of a fully charged battery cell depends upon the proportion of sulfuric acid to water in the electrolyte. The battery manufacturer can provide the precise electrolyte information. Once known, cell voltage can be determined by the formula below.

At 77 degrees F vpc = Specific Gravity (SG) +. 84

A battery with a SG of 1.250 would have a fully charged cell voltage of 2.09 V. Add .001 to SG for every 3 degrees over or subtract .001 for every 3 degrees under 77 degrees F.

Measuring the SG of a battery can be tricky. Accurate hydrometer (or voltmeter) reading can only be obtained after the battery has sat open cell (no current in or out) for several hours. Hydrometer readings must be taken before adding water as electrolyte mixing can take several weeks or even months. Also, hydrometer readings will vary across cells if water levels differ. Low level cells will read higher.

Before measuring new batteries for SG, form them first. Fully charge them at 2.35 vpc and then discharge them to 1.85 vpc. Recharge them at 2.35 vpc for three days. Replenish water and leave the batteries at 2.25 to 2.27 vpc for a few weeks. This process mixes the electrolyte and forms the new battery by leaving a firm voltage and polarity imprint. Accurate open cell SG readings can now be taken.

In a formed battery, after equalizing and mixing, if a .025 SG difference is showing between any 2 cells, replace the battery. **When using a hydrometer, use gloves and wear protective eye wear.**

Float and Equalize Voltage Settings

Float voltages for batteries in marine service vary. The Quality Marine chargers adjust to accommodate any marine battery. Adjustment ranges and "rule of thumb" charge voltages are shown below. Float can also be established by monitoring battery water loss. Consult the manufacturer of your batteries for precise float and equalize settings.

Adjustment Range of Quality Marine VM & ***VMI*** Chargers

12 V units: 12 – 16 V, 24 V units: 24 – 30 V, 32 V units: 32 - 40V

Typical Lead Calcium Voltages/ Starting Batteries

Starts to charge at	2.1 vpc. (12.6 V)
Full charge	2.15 vpc. (12.9 V charger off 24 hours)
Starts to gas at	2.3 vpc. (13.8 V)
Float setting	2.2 vpc. (13.5 V)

Equalize at 2.35 vpc (14.1 V) every 3 to 4 months for 8 to 24 hours.

Note: Lead calcium batteries generally do not need equalizing if they are never let below 2.2 vpc (13.2 V).

Typical Lead Antimony Voltages /Deep Cycle Batteries

Starts to charge at	2.05 vpc. (12.3 V)
Full charge	2. 1 vpc. (12.6 V charger off 24. hours)
Starts to gas at	2.2 vpc. (13.2 V)
Float setting	2.2 vpc. (13.2 V)

NOTE – Lead antimony batteries should be equalized every 2 months at 2.33 to 2.35 vpc (14.0 V) for 8 to 24 hours.

Gel Filled Batteries

Generally of lead calcium design, gel batteries offer the combined capability of lead calcium and lead antimony batteries e.g. cranking and cycle ability. Further benefits are found in their potential long life and the fact that they are sealed to prevent hydrogen gas emissions. However, to protect the life and enjoy the benefits of expensive gel batteries, careful charging procedures must be adhered to.

Because all lead calcium grids have a tendency to heat up and grow in deep cycle applications, or when over charged, particular attention must be paid to the ambient temperature of gel batteries. As temperature increases, the charge voltage must be reduced. Remember, engine rooms heat up. Establish compromise voltages and check alternators. Please note, recharge voltages of more than 2.4 vpc can destroy some gel batteries in 16 hours or less when hot.

Typical Gel Battery Voltages

Starts to charge at		2.12 vpc. (12.72 V)
Fully charged at		2.15 vpc. (12.9 V charger off 24 hours)
Sealed to prevent gas emission.		
Float voltage	@ 70 degrees F	2.3 vpc. (13.8 V)
	@ 86 degrees F	2.25 vpc. (13.5 V)
	@ 100 degrees F	2.22 vpc. (13.3 V)

At 70 degrees F, equalize at 2.35 vpc every 3 to 4 months for 8 hours.

Charging Dead Batteries

Charge dead batteries at equalization voltage for 8 to 24 hours, then, re-set the charger to float voltage. Check the water level before and after charging. Do not overfill before charging as electrolyte will rise as charging begins. After a few hours, make sure that voltage is coming up on the battery and that it is indeed capable of taking a charge. Make sure the battery compartment is ventilated. **Never charge a frozen battery!**

Multi-Bank Charging

Most Quality Marine chargers will charge up to 3 battery banks simultaneously. Remember, the charger can only be adjusted to one float voltage setting. The multi-bank outputs should not be used to charge banks where the batteries are of different design with different float requirements. Example: Gel or lead calcium starting batteries on one bank and lead antimony, deep cycle, house batteries on another.

Multi-bank charging is not recommended when one bank is used for heavy cycle service and the other not. No charger, using diode isolators to charge multi-banks, can totally eliminate some charging into a fully charged bank while charging a depleted one. Charging activity on the cycling bank will exercise the inactive banks and shorten their life. Load support to the primary service or house bank will be compromised by the fully charged banks. Avoid problems by asking your Quality Marine representative about paralleling banks.

Battery Chargers and Noise

Battery chargers can generate noise in the form of electromagnetic interference (EMI), which is conducted throughout the ships wiring, or transmitted noise called radio frequency interference (RFI). Most noise will occur, or increase, at high end of the chargers output capability. When noise is being generated, it is disruptive to electronic equipment, e.g. radios, TVs, and stereos. To reduce EMI or RFI, observe the following guidelines.

1. Observe grounding instructions for the battery charger and all other equipment.
2. The battery bank itself is a good filter for noise. Never connect the charger to the panel or battery switch. Always connect the charger directly to the battery. The larger the battery bank, the less noise will be experienced. A good rule of thumb is to ensure the battery charger's maximum current output does not exceed 10% of the ampere hour rating of the battery bank. If a charger larger than 10% is needed to support the load, the capacity of the battery bank should be increased. Also, a bad cell, or bad battery in a bank, will result in more noise being passed across the bank.
3. Never bundle charging leads in with wire harnesses that lead to other areas of the boat or to the electronics. Make sure charging leads are adequately sized.
4. Consider the load requirement in amps, and provide a model of charger that does not have to work continuously at 100% to keep up.
5. Most wheel house electronics e.g. radars, sounders, etc. are, not, sensitive to charger noise. However, VHF, SSB, and stereo receivers are. The power leads of these types of equipment can be filtered. On large vessels, a common practice is to power radios with separate radio power supplies. In this case, switches can be provided to switch the radios back to the battery source in the event of an AC power failure.

Electrolysis Protection

Quality Marine chargers are equipped with isolation transformers to protect against shock and AC electrolysis. Quality Marine chargers will not protect your boat from electrolysis caused by other devices.

Customer Service

Quality Marine, LLC is proud of the products we provide to the marine market place and appreciate our customers. We will do our best to support you and resolve any problems or questions in an expedient manner.

Contacts:
Quality Marine, LLC
16303-A N.E. 15th ST.
Vancouver, WA 98684
360 253-2180
www.qualitymarinechargers.com

Technical Support:
800-463-5314
Fax: 360 914-9087
E-mail: www.qualitymarinechargers.com

Representative: Technical & Sales
Ron Smith
4414 30th Ave. W.
Seattle, WA. 98199
PH: 206-283-9868
FX: 206-283-9236
www.rsimarineproducts.com

Battery Charging, Things That Make a Difference

- Keys to Long Battery Life -

1. Voltage Regulation – Quality Marine VM & ***VMI*** SCR battery chargers regulate to +/- 1% of the set float voltage across current output, even as line voltage varies +/- 10%, or frequency varies +/- 5%. At proper float voltage, Quality Marine's precise regulation minimizes battery water loss and grid corrosion, while maximizing battery life.

2. Proper Setting of Float Voltage – Quality Marine chargers are equipped with an adjustment for setting float voltage. They are delivered from testing at about 2.21 volts per cell (vpc) e.g. 13.3 volts on the 12 volt models. Consult the battery manufacturer on float voltage specifications, or see attached introduction to batteries and battery charging.

3. Periodic Battery Cell Equalization - The Quality Marine charger float voltage adjustment can be used to equalize batteries. This should ideally occur every 2 months. This adjustment can also be used when rapid charging is required. The ***VMI*** series charger has a built in Equalize timer in which a separate equalize voltage can be set independent of the float voltage setting. The equalize voltage will be maintained until the timer times out and the charger will return to the set float voltage.

4. Sizing the Charger to Anticipated Load – Quality Marine chargers are built to deliver 100% of their rated current to meet the load demand while maintaining the battery at a set float voltage. This ability prevents a battery discharge cycle and thereby increases battery life. Select a charger with a current rating at least 25% greater than the anticipated average load.

5. Battery Maintenance - Proper cable sizing, clean and tight connections, and battery water levels significantly add to battery life. Use distilled water.

6. Multi-Bank Considerations - No multi-bank charger can totally eliminate some charging into a fully charged bank when simultaneously connected to a cycling bank. A chargers output to a heavily used bank will be compromised when connected to a fully charged one. Do not apply multi-bank charging to batteries of different design, e.g. ni-cad, lead calcium or lead antimony deep cycle batteries.