Batteries made simple

Introduction

Selecting the correct batteries for the application, whether engine start or house batteries, can be the difference between happy and contented use or an exercise in crisis management. The object of these few pages is to assist vehicle, boat or motorhome owners to understand what is happening to the batteries, what makes the various types different and what effects the life and performance. Commonly the starting battery provides very high current for a short discharge period resulting in only around 1% of the capacity being discharged. This is easily recovered by the charging system. Conventional “Automotive” type charging systems provide an adequate environment for Engine Start Batteries. This is not the same for Deep Cycle Batteries and careful matching of load, battery capacity and recharge need to be factored.

Basic Principles - Flooded Lead Acid Batteries

This section deals with the basic principles of the battery and the figures quoted generally apply to conventional “wet” batteries which are the most commonly used in a marine environment. Different types of batteries are explored in a later section. Most of the problems are experienced with “House Batteries” as these are the ones doing a lot of work. In electrical systems volts is the electrical pressure and the electrical flow is the amps. The amount of flow is dependent upon the restrictions in the electrical circuit called resistance. The battery simply stores power. If the battery is not charged at the right pressure or does not receive adequate charge because of the amount of current flow or the duration of charge, then it will not be able to deliver if required. It is worth noting that small variations in charging voltages have significant effects. A half charged battery has a terminal voltage of 12.2 volts. If we look at the difference between a charging system supplying 13.8 volts to the battery or 14.5 volts, the difference in electrical pressure which is pushing the charge current into the battery is in the first instance 1.6 volts and in the second instance is 2.3 volts. Whilst the actual difference is only 0.7 volts this represents a 43% higher charging voltage which will roughly represent the increase in charge current or capacity gained by the battery in a given charging period. Batteries and electrical systems can be likened to water tanks and water flow. The battery is the storage tank. It has a positive pressure outlet and a negative pressure return and the electrical system operates on a closed piping system. The alternator is simply an electrical pump which is used to refill the tank.

Charging the Battery

The alternator or battery charger is simply an electricity producing pump which generally has a voltage (pressure) restricting device on it called a regulator. To force electrical current back into the battery the voltage of the alternator needs to be higher than the voltage of the battery. If the voltage is too low (at the battery) then not enough storage capacity will be achieved. If the voltage is too high then the battery will be damaged. As with water tanks, the more full (or charged) the battery is the higher the back pressure. So with a fixed inward voltage and a growing back pressure the current flow into the tank steadily tapers downwards.

Some Special Characteristics of Batteries

Ventilation

When the battery nears a full charge condition bubbles of hydrogen and oxygen gas are produced which leak out of the battery by way of the vent plugs. This condition is normal but does require that all batteries are placed in a ventilated space. Some types of batteries do not produce any gas in normal working conditions but if overcharged even these batteries will produce gas which can be dangerous meaning that ventilation is required for all battery types.

Safety

When a battery is being recharged dangerous gases (hydrogen and oxygen) are given off by the battery. More gas is produced at higher charge voltages. If ignited by a mere spark, this mixture will explode and can cause serious injury. Most at risk are the eyes so when working around or on the batteries, particularly during or after charging, always wear safety glasses.

Float Charge

Once the battery is charged, a longer battery life will be achieved if the charging voltage being applied by the alternator is reduced. A continued application of the normal recharge voltage results in deterioration of the internals of the battery preventing it from holding or delivering as much capacity. The reduction of the charging voltage, once the battery is charged, is called putting it on “float”. However, even a float charge can cause corrosion of the positive plates. Some superior chargers totally turn off, monitoring the battery sate of charge and turning back on when required. Continuous float charging of engine starting batteries is not recommended as a reduction in life is inevitable.

Sulphation

If the battery is left flat or partially charged it develops a condition called sulphation which inhibits the current flow into the battery during recharge. This condition could be likened to a build up of “sludge” in a water tank which effectively increases the back pressure which results in less inward flow. Severe Sulphation can render the battery useless.

Maintenance

The action of charging also causes the loss of water in most batteries and has to be replaced by topping up with clean water. In the case of sealed batteries, if over charged, the loss of this water will still take place and permanently damage the battery as it cannot be replaced. Obviously terminals should be kept clean and dry.

Maintaining Capacity

The action of charging and discharging the battery causes a change in the consistency of the electrolyte. When the battery is charged acid is produced which is more dense or heavy than the electrolyte. When the battery is discharged water is produced which is lighter than the electrolyte. As a result the water floats on the top of the heavier acid. This is called “Acid Stratification”. When the battery is recharged to near full charge the resulting higher voltage causes production of the bubbles of hydrogen and oxygen which gradually move up through the electrolyte and out through the vent plugs in the top of each cell. The movement of these bubbles up through the electrolyte has the effect of mixing the acid. This mixing process is vital to achieve long battery life as Acid Stratification increases the incidence of Sulphation. When house batteries are subjected to normal charge/discharge use, unless subjected to long engine running times or shore power charging (or similar), the battery is rarely fully charged. The lead sulphate found in the plates (a normal condition) will “harden” over a period of time and is difficult if not impossible to remove. This results in a loss of capacity. This loss of capacity is progressive and cumulative and will result in reduced performance and life.

Depth of Discharge

If the battery is repeatedly drained to low levels of capacity the life will be less than if it is only partially discharged. This is called the depth of discharge or DoD. The greater the DoD, the shorter the life.

Temperature Compensation

When a battery is heated it requires lower charging voltage to receive the correct charging current. Accordingly a lower charge voltage should be applied as the temperature increases. This is called temperature compensation.

Battery Environment

As a chemical device the activity inside the battery is affected by temperature. A common cause of battery failure is grid corrosion. This is the gradual deterioration of the lead grid/plate which is corroded by the electro-chemical action. The rate of this corrosion is increased with the temperature surrounding the battery when the battery is being recharged. From this it is quite clear that house batteries in particular will last longer if installed in a cool place as opposed to the engine room which is quite common, even if the temperature compensated charging is applied.

The Difference Between Car & Marine Batteries

Batteries fitted to cars are required to provide a very high cranking current to start the engine for a short time. After this is achieved the battery simply receives charge from the alternator. Only rarely is the battery required to deliver power for any duration of time. To achieve high cranking current output, the manufacturer uses very thin plates made in such a way that the acid has good access to the active material which is producing the current. If you put this type of battery into a marine environment, particularly to provide long and deep discharge periods the battery is likely to have a short life.

The Difference Between Marine Engine Start & Deep Cycle Batteries

Marine batteries fall into two categories. Engine Start and House Batteries. The Engine Start type is of similar construction to the car battery but in a well built battery will be manufactured in such a way to prevent damage caused by shock and vibration. In general terms the marine battery will be of a more robust construction as car batteries tend to be built to a price rather than a standard. When a battery is regularly charged and discharged, this causes deterioration of the positive plate. Deep cycle batteries, in simple terms have a thicker plate and a more dense active material which is able to withstand the pressures of this type of use.

Plates/Capacity - A popular misconception

As described above, plate thickness varies widely and therefore cannot be used as an indication of capacity. To give an example, a high performance engine starting battery with 22 plates per cell is available in NZ and is approximately 65 ampere hours in capacity, whilst another battery of 350 ampere hours has only 15 plates per cell. When specing a battery it is important that the application is considered. For example when engine start is required then the SAE or DIN CCA (cold cranking amps) rating is an indication of the battery’s ability to start an engine, whilst for auxiliary loads ampere hour capacity is what you need to consider.

Alternative Lead Acid Battery Types

General

Batteries are broadly broken into two categories. The most common is the “wet” or “flooded” technology. This is the conventional type which in principle is largely unchanged from the original design going back over the last 100 years. However significant gains in efficiency, charge acceptance, maintenance requirements and energy output have been achieved. Without doubt as a percentage of weekly income, batteries have never been cheaper and the warranties never longer. Of more recent times the Valve Regulated Lead Acid (VRLA) type, often called “sealed” has been introduced. Some confusion does exist over this type of product as often the battery is a flooded type but maintenance free, not requiring top up of electrolyte. There is also some confusion over "Gelled Electrolyte" and the alternative VRLA "Absorbed Electrolyte" or "Absorbed Glass Mat" (AGM) technologies. The following passages will hopefully reduce some of this confusion.

Flooded Batteries

Most of the information provided in the previous pages pertains to "Flooded" batteries. However within this range two types of construction does exist. By far the most common is the "Flat Plate" construction. This is available in maintainable and "maintenance free" configurations. In simple terms the manufacturer alters the alloys used to manufacture the battery so that only very small amounts of Hydrogen and Oxygen gas are produced during charging. This results in minimal water consumption over the life of the battery. However it should be noted that if tipped over this battery will sometimes leak. In larger installations where high levels of storage capacity is required, batteries come in the form of 2 volt cells connected in series to make up the required voltage. The reason for this is simply for ease of handling. In the two volt cell form "Tubular Positive" batteries are available. This involves a different method of construction of the positive plate of the cell, which is very robust and resistant to deterioration caused by deep and regular cycling. This product is generally manufactured in Europe and is usually more expensive, but over the life, dependent upon application, can represent good value.

Valve Regulated Batteries

A number of years ago it was discovered that by changing the internal construction of the battery and maintaining a positive pressure (3 to 5 psi) inside the battery, it was possible to get any Hydrogen or Oxygen gas that may be produced during charging to recombine internally. This resulted in allowing the battery to be installed without fear of acid spillage, emission of corrosive gas and almost zero maintenance. In some cases this type of product can be installed on its side and will work whilst submerged without the production of any chlorine gas which is often produced when a flooded battery comes in contact with salt water. As briefly mention above, within the VRLA group two different types of technology exist. The most commonly used in a marine environment is the Gelled Electrolyte. Provided it is well manufactured, this type of product provides good cycling characteristics with all the benefits of a valve regulated product. The electrolyte is in a "jelly" form so no spillage is possible. The second type uses a material like blotting paper made from glass fibre to retain the electrolyte. This method also removes any loose electrolyte from sloshing around which may spill or leak. Independent tests tend to demonstrate that the Gelled Electrolyte type are better suited to a cycling (charge flat) application like marine house batteries than the AGM type. In reality the VRLA battery is not everything to everyone

(contrary to claims commonly made by various battery companies) and have had significant reliability problems in the past. Some of these problems can be blamed on factors not provided by the battery itself but in truth the VRLA battery is more "delicate" than the tried and proven flooded battery. This delicacy means that unless the battery is manufactured to perfection and well cared for it could provide a shorter life than a cheaper alternative. To provide an example: If a vessel suffered regulator failure during a voyage and the batteries were over charged, in the case of flooded batteries, the lost water would be topped up and would suffer little damage (provided the regulator was replaced within a reasonable time). In the case of VRLA batteries (depending upon running time) it is possible, if not likely that the batteries would require replacement along with the regulator. Now this is not to say that VRLA batteries do not provide a good or even the best option in some instances but these options need to be explored, ideally with someone who knows what he is talking about and can provide all of the options not just one technology. When evaluating the different types, be careful of claims of high cycle life etc. backed up by specific figures. In recent times this type of claim has been made pertaining to an AGM product where the cycle life data is based on a one-hour discharge. Obviously this is not applicable to a normal marine application and the reason that this data was used is because if tests were done over a normal 20 hour discharge the cycle life results would not be as good as equivalent gelled product. It is worth noting that a large American manufacturer of Flooded, Gelled and AGM batteries and therefore with no axe to grind, clearly states that Gelled is better suited than AGM for cycling applications. Who could argue with that?

Recombinant Vent Plugs

This is an interesting product which provides all of the maintenance and ventilation benefits of a VRLA battery to a flooded battery whilst retaining all of the resilience and integrity of the flooded type. Comprising a palladium catalyst fitted to the vent plug, the hydrogen and oxygen gas is recombined back into water in the vent plug but external to the battery and returned to the cell.

Summary

1. A battery stores charge it does not "Manufacture" it
2. Insufficient charging voltage will cause poor battery performance
3. Insufficient charging voltage will cause short battery like
4. Excessive charging voltage will cause short battery life
5. Leaving a battery partially charged will reduce life and performance
6. Periodically batteries need to be fully charged to maximise life and performance
7. Engine Starting Batteries are required to deliver high current for a short time. If this type of battery is subjected to many cycles of charge/discharge a short life is likely
8. Deep Cycle Batteries are designed for a charge/discharge usage but can start engines in emergencies.
9. Life is reduced by a warm temperature environment.
10. Not all Valve Regulated Batteries are the same.
11. Valve Regulated Batteries have good features and benefits but are more "Delicate" than flooded batteries.