Powering up Your Camper Trailer

Sir, Do you want power with that?

Camper Trailers and 12 volt electrical systems.

So you have just purchased your CT and said no to the salesman when he said “Do you want power with that?”.

Now you decide that it might be a good idea but are not sure where to start.

I hope these notes are of some use.

The System

A power system for your CT is more than just a battery stuck somewhere to run your fridge, lights, laptop, TV, CD player etc etc.

It also has to include some way of replenishing the battery that supplies all the go juice for the above goodies.

There are four ways of doing this,.

A stand alone Generator

The tow vehicle Alternator

Solar panels

240 household power and battery charger

Or a combination of all four if you like.

Sizing the system

The best starting ponit is to establish what sort of camping you will be doing if you haven’t already done so.

Long trips with lots of one night stays

Or

Trips from A to B where you stay at B for several days and either go back to A or go on to C. etc.

Why start here? Because it will help establish the sort of Fridge you want to buy and that in turn has a major impact on designing your 12 volt system.

The Fridge

While there are many other considerations re the Fridge than just one night stays vs. long stays, it is worth a quick look at the issues involved.

There are two basic types of fridge – 3 way and 12 volt only.

3 way is 12 volt, gas and 240 volt and until recently did not come with freezer capability. They do not have a compressor but rather work on the same principle as an old Kerosene Fridge. I.e. use heat to heat gas which circulates and cools the fridge.

For long stays the 3 way is run on gas. On the move they are run on 12 volt. Their 12 volt consumption can be quite high. About equivalent to a headlight on high beam, depending on make and model. They also need a bit of work to get them to run effectively on 12 volts.

The 12 volt types have small compressors and fit into two basic families, the conventional (Engel) type and the Eutectic type. The latter still uses a compressor but uses a different principle for keeping the contents of the fridge cold. A freezing solution in the walls, means the fridge compressor runs a lot less than a conventional 12 volt fridge. These fridges are apparently a lot less hungry on power than the conventional 12 volt type.

Full explanations of these fridges and their power consumptions is available in plenty of places on the Internet and I don't intend to discuss that aspect of their operation here.

So, what is the point.? The point is this.

Having decided on the fridge type based on style of camping and other considerations like freezer, size, personal preferences etc etc then:

> **If you want a 12 volt fridge with freezer your system has to be designed to cope with this.**
>
> **If you are happy with a 3 way then you can design a different and probably smaller system.**

The rest of the gear

This involves listing all the appliances including the fridge that you will be running and calculating how long they will run in a 24 hour period and so establishing their power usage. This is normally expressed in Amps per hour.

Running a couple of lights for say 4 hours an evening will normally draw a minimum 8 amps out of your battery.

Again, there are spreadsheets available on the internet and even the Camper Trailer site that will help you do these calculations.

The section on Volts, Amps and Watts later in these notes explains in a bit more detail what this means, and contains some examples.

When the total power requirements have been established you can then size your battery and at the same time make some decisions about how it will be replenished.

Most people will find a 100 to 150 amp hour battery will be more than adequate for their needs.

The next decisions are then mostly financial and convenience driven.

Understanding how to size your requirements.

For some people the relationship between Volts, Amps and Watts is a complete mystery.

These notes are intended to give just a basic understanding of how the three relate to each other without actually understanding exactly what they are.

The internet is full of sites that will do just that. A good well constructed Google search will find all the detailed technical explanations anyone could need. Including multiple conflicting definitions of some aspects of the subject.

The only areas of almost complete agreement are in the definitions of Volts, Amps and Watts and their strict relationship with each other. Here we are on solid ground.

Once you know how the three relate you can begin to size your system.

In actually **constructing** your system a little knowledge of Ohm's law which talks about resistance is useful as this law helps determine cable size to avoid excessive voltage drop. Even Dick Smith Stores (on line) has detailed step by step instructions on how to size cable.

The most mentioned acceptable voltage drop for efficient operation of fridges etc is around 2% – 3%.

Other sites have built in calculators that will tell you the size of cable for the required voltage drop over the stated length. **<u>You need to measure the length of both positive and negative cable length, not just the length of the cable one way.</u>**

There is also a formula later in this little book that will calculate the Voltage Drop for any size wire you choose, if you know the length of wire and the Amp draw. It is very simple and doesn't need a technical knowledge of Ohm's Law.

The Basic Elements

Before we start, a recap on the two types of electricity we are all familiar with.

AC/DC Electricity

> **DC** stands for direct current and is found in batteries and solar panels. Most cars have DC light bulbs and DC stereos meaning they are hooked up to your cars battery. DC electricity flows in the same direction, negative to positive**. DC electricity can be stored. That's what batteries do. From the humble aa to car batteries.**
>
> **AC** is alternating current and is usually found in households. This type of electricity reverses direction of flow many times per second**. AC power cannot be stored.** All electricity wants to do work, so AC is like the ocean's waves. If you put a water wheel at oceans edge the incoming tide would do work one way and the outgoing tide would do work the other way. Both in and out create work. Just like AC power.

Another basic bit of information is

Series and Parallel Circuit Wiring

> **Series** - Negative to positive. This doubles the voltage and keeps the amps the same. If two 6 volts golf cart batteries are connected this way the voltage doubles to 12 volts and the amps remains the same.
>
> **Parallel Circuit** - Positive to positive or negative to negative. Voltage remains constant, but the amps double. Most solar panels in the RV application should be paralleled so that the voltage remains the same at 12 volts but the amps double.
>
> This is the way you jump start a car.

A little about wires

Conductors (wires) are always full of movable electric charges. **Voltage** pushes charges through the conductive object which has a certain amount of electrical resistance or "friction," and this heats up the resistive object.

The flow rate of the moving charges is measured in **amperes**, while the transfer of electrical energy as well as the rate of heat output is measured in **watts**.

The electrical resistance is measured in **ohms.**

Volts, Amps and Watts

Volts, Amps and Watts is what it is all about. They are easy to understand and necessary.

The simplest to start is with a 60 watt light bulb. A 60 watt light bulb over one hour will use 60 watts of energy. A 100 watt light bulb will use 100 watts in an hour and so on.

The basic math formula for understanding their relationship is

Watts = Volts times Amps.

In practical camping terms a 60 watt headlight bulb from a car draws 5 amps. Left on for an hour it will suck 5 amps from your battery. 60 (Watts) = 12 (Volts) x amps. So amps here are 5 and both headlights are 10 amps draw. Leave both on for an hour and you draw 10 amps from your battery or you bring an 80 amp hour battery down to 50% SOC (state of charge) roughly in 4 hours (4x10=40 which is half the 80 amp hour rating of the battery).

Or a 16 watt two tube camping fluro draws 1.33 amps

16 = 12 x amps . So amps here are 1.33 (16/12).
(Watts = volts x amps)

Definitions

Volt: Voltage; The unit of electromotive force (EMF) that causes current to flow. One volt causes a current of one amp through a resistance of one ohm.

Amp: (ampere named after French physicist André Marie Ampère (1775-1836). The basic unit of current in an electrical circuit. One ampere is the rate of flow of electric current when one coulomb of charge flows past a point in the circuit in one second. Symbolically characterized by the letter "I" and sometimes "A" when used in formulas.

Put another way, amps is the number of energies or workhorses that flow past. So when you buy a vacuum the one that has the bigger amp number is more powerful. It has lots of energy running past to make a stronger suction

Watt: The unit of power. One watt equals one joule per second, 1/746th horsepower. is the combination of volts and amps.

From the math equation, Watts is equal to Volts times Amps. For example, a solar panel that is rated at 17.0 volts and 5.88 amps of energy (17.0 Volts x 5.88 Amps) would produce 100 watts per hour of electricity. Remember a 100 watt light bulb uses 100 watts in an hour. This solar panel would produce 100 watts per hour. So if you stored this 100 watts of solar power in a battery you could use it in the evening to run the light bulb for one hour.

Watt-hour: The power of one watt operating for one hour, and equal to 3,600 joules. (60 seconds x 60 minutes x 1 joule per second)

Ohm: The unit by which electrical resistance is measured. One ohm is equal to the current of one ampere which will flow when a voltage of one volt is applied. The current flowing through a load is directly proportional to the voltage applied to the load. I.e. doubling the voltage doubles the current.

This is known as Ohm's Law.

We end up with R(ohms) = V(volts) / I(amps).

For practical purposes, most wires used in camping situations offer little resistance over short distances.. However the resistance caused by thin wires and distance is important when powering 12 volt appliances especially fridges, The resulting voltage drop is a major factor in poor 12 volt fridge performance.

Voltage Drop: The difference in potential measured between two points caused by resistance or impedance.

Formulae

Again, a Google search of the Internet will locate sites that are purely devoted to technical formulae. These include mountains of data related solely to electrical matters.

Which makes sense, as most electrical work involves either 240 or 120 volts in domestic and industrial situations and is tightly regulated with government set standards. This stuff can after all kill you real quick!.

All 12 volts can do is give a nasty burn and maybe set your CT on fire.

If it does, it is the fire that kills you, not the 12 volts!

So, when wiring, use fuses of the right size in the right places, especially close to the battery. That way you blow a fuse, not your wiring and yourself.

Voltage Drop

Having covered some of the basics we can now talk about how to measure voltage drop.

A primary concern when installing lengths of wire is voltage drop. The amount of voltage lost between the originating power supply and the device being powered can be significant. Improper selection of wire gauge can lead to an unacceptable voltage drop at load end.

Electrical standards for voltage drop allow for 5% losses in the American market. Australian standards allow the same. This is in domestic and commercial applications.

The lower the loss the better but in the end it is a trade off between cost and convenience of wiring. A 3% loss is achievable without too much drama.

Voltage drop calculations use Ohms Law as the basis of their calculations. There are many approaches ranging from calculating the drop to calculating the wire needed for a specified distance with a pre-determined drop. Also there are numerous free on line calculators available. Unfortunately most are for the American market and are expressed in feet and AWG wire sizes.

The calculation below is from the UK and is simple to use for most 12 volt camper trailer installations. Bear in mind that with variations for temperature and type of wire, this formula does not give a precise result, but it is more than adequate for our purposes. especially if you err on the conservative side in choosing wire size, i.e. go a little bit thicker..

VOLT DROP CALCULATIONS

E= (0.0164 x I x L)/S

E = Volts drop in volts

I = the load current in amperes

L = the total length, in meters, of conductor from the positive power source connection to the electrical device and back to the negative source connection.

S = the conductor cross-section area in square millimetres

You wish to install two 12V, 20 W lights in a camper.. The current drawn by the light will be (2x20/12) 3.23 amps. You calculate that the length of the wiring loop is 15 metres from the battery source and back. Also you are using 2.5 mm^2 wire which is between the AWG 12 and 14 size.

So we have

E= .0164x3.23.x15 = .79458

.79458/ 2.5 = .3178

So, voltage drop is .32 volts (approx) which is 2.6% drop, (.32/12) about right.

Using this simple formula will save a lot of grief in installations for devices that are intolerant of less than optimal voltages. Eg most things with motors, especially fridges.

If the voltage drop is too high, then try a wire with a larger mm2.

(Another approach is to follow the example on the Dick Smith Stores Web site.)

Now that you have an idea on the wire size and no doubt the lengths you will need, the next step is the battery location and type.

Locating the System

Two choices here. In the CT or in the tow vehicle either under the bonnet or elsewhere. Personal choice plays a part here as well as space limitations. Some newer vehicles just do not have room under the bonnet for extra batteries.

Both have their pluses and minuses. In the CT would usually mean a sealed battery while under the bonnet just a normal battery with caps.

The basics of solar power:

Using solar power to produce electricity is not the same as using solar to produce heat. Solar thermal principles are applied to produce hot fluids or air. Photovoltaic principles are used to produce electricity. A solar panel (PV panel) is made of the natural element, silicon, which becomes charged electrically when subjected to sun light.

This electrical charge is consolidated in the PV panel and directed to the output terminals to produce low voltage (Direct Current) - usually 6 to 24 volts. The most common output is intended for nominal 12 volts, with an effective output usually up to 17 volts.

A 12 volt nominal output is the reference voltage, but the operating voltage can be 17 volts or higher much like your car alternator charges your 12 volt battery at well over 12 volts. So there's a difference between the reference voltage and the actual operating voltage.

Components used to provide solar power:

The four primary components for producing electricity using solar power, which provides common 240 volt AC power for daily use are: Solar panels, charge controller, battery and inverter. Solar panels charge the battery, and the charge regulator insures proper charging of the battery. The battery provides DC voltage to the inverter, and the inverter converts the DC voltage to normal AC voltage.

Solar Panels:

The output of a solar panel is usually stated in watts, and the wattage is determined by multiplying the rated voltage by the rated amperage. The formula for wattage is VOLTS times AMPS equals WATTS. So for example, a 12 volt 60 watt solar panel measuring about 20 X 44 inches has a rated voltage of 17.1 and a rated 3.5 amperage.

V x A = W
17.1 volts times 3.5 amps equals 60 watts
If an average of 6 hours of peak sun per day is available in an area, then the above solar panel can produce an average 360 watt hours of power per day; 60w times 6 hrs. = 360 watt-hours.

Since the intensity of sunlight contacting the solar panel varies throughout the day, we use the term "peak sun hours" as a method to smooth out the variations into a daily average.

Early morning and late-in-the-day sunlight produces less power than the mid-day sun. Naturally, cloudy days will produce less power than bright sunny days as well.

Solar panels can be wired in series or in parallel to increase voltage or amperage respectively, and they can be wired both in series and in parallel to increase both volts and amps. Series wiring refers to connecting the positive terminal of one panel to the negative terminal of another.

The resulting outer positive and negative terminals will produce voltage the sum of the two panels, but the amperage stays the same as one panel. So two 12 volt/3.5 amp panels wired in series produces 24 volts at 3.5 amps. Four of these wired in series would produce 48 volts at 3.5 amps.

Parallel wiring refers to connecting positive terminals to positive terminals and negative to negative. The result is that voltage stays the same, but amperage becomes the sum of the number of panels. So two 12 volt/3.5 amp panels wired in parallel would produce 12 volts at 7 amps. Four panels would produce 12 volts at 14 amps.

Series/parallel wiring refers to doing both of the above - increasing volts and amps to achieve the desired voltage as in 24 or 48 volt systems. The following diagram reflects this. In addition, the four panels below can then be wired in parallel to another four and so on to make a larger array.

Charge Controller:

A charge controller monitors the battery's state-of-charge to insure that when the battery needs charge-current it gets it, and also insures the battery isn't over-charged. Connecting a solar panel to a battery without a regulator seriously risks damaging the battery and potentially causing a safety concern.

Charge controllers (or often called charge regulator) are rated based on the amount of amperage they can process from a solar array.

If a controller is rated at 20 amps it means that you can connect up to 20 amps of solar panel output current to this one controller.

The most advanced charge controllers utilize a charging principal referred to as Pulse-Width-

Modulation (PWM) - which insures the most efficient battery charging and extends the life of the battery.

Even more advanced controllers also include Maximum Power Point Tracking (MPPT) which maximizes the amount of current going into the battery from the solar array by lowering the panel's output voltage, which increases the charging amps to the battery - because if a panel can produce 60 watts with 17.2 volts and 3.5 amps, then if the voltage is lowered to say 14 volts then the amperage increases to 4.28 (14v X 4.28 amps = 60 watts) resulting in a 19% increase in charging amps for this example.

Battery:

The battery should have sufficient amp hour capacity to supply needed power during the longest expected period "no sun" or extremely cloudy conditions. A lead-acid battery should be sized at least 20% larger than this amount. If there is a source of back-up power, such as a standby generator along with a battery charger, the battery does not have to be sized for worst case conditions.

The size of the battery required will depend on the storage capacity required, the maximum discharge rate, the maximum charge rate, and the minimum temperature at which the batteries will be used. During planning, all of these factors are looked at, and the one requiring the largest capacity will dictate the battery size.

Lead-acid batteries are the most common in Solar systems because their initial cost is lower and because they are readily available nearly everywhere in the world. There are many different sizes and designs of lead-acid batteries, but the most important designation is that they are deep cycle batteries. Lead-acid batteries are available in both wet-cell (requires maintenance) and sealed no-maintenance versions. AGM and Gel-cell deep-cycle batteries are also popular because they are maintenance free and they last a lot longer.

Using an Inverter:

An inverter is a device which changes DC power stored in a battery to standard 240 VAC electricity. Most solar power systems generate DC current which is stored in batteries. Nearly all lighting, appliances, motors, etc., are designed to use ac power, so it takes an inverter to make the switch from battery-stored DC to standard power.

In an inverter, direct current (DC) is switched back and forth to produce alternating current (AC). Then it is transformed, filtered, stepped, etc. to get it to an acceptable output waveform. The more processing, the cleaner and quieter the output, but the lower the efficiency of the conversion. The goal becomes to produce a waveform that is acceptable to all loads without sacrificing too much power into the conversion process.

Inverters come in two basic output designs - sine wave and modified sine wave. Most 240VAC devices can use the modified sine wave, but there are some notable exceptions.

Devices such as laser printers which use triacs and/or silicon controlled rectifiers are damaged when provided mod-sine wave power. Motors and power supplies usually run warmer and less efficiently on mod-sine wave power. Some things, like fans, amplifiers, and cheap fluorescent lights, give off an audible buzz on modified sine wave power. However, modified sine wave inverters make the conversion from DC to AC very efficiently. They are relatively inexpensive, and many of the electrical devices we use every day work fine on them.

Sine wave inverters can virtually operate anything. A sine wave inverter is equal to or even better than utility supplied power.

One of the biggest mistakes made by those just starting out and using inverters is not understanding the relationship between amps and amp-hour requirements of 240 volt AC items versus the effects on their DC low voltage batteries. For example, say you have a 12 volt system and an inverter powering a load of 1 amps, 240VAC, which has a duty cycle of 4 hours per day. A 3 way fridge on 240 volts draws .3 of an amp. (75 watts) so I amp at 240 volts is quite a load.

You would have a 4 amp hour load (1A X 4 hrs=4 ah). However, in order to determine the true drain on your batteries you have to divide your nominal battery voltage (12v) into the voltage of the load (240v), which is 20, and then multiply this times your 240 vac amp hours (20 x 4 ah). So in this case the calculation would be 80 amp hours drained from your batteries - not the 4 ah.

Another simple way is to take the total watt-hours of your 240VAC device and divide by nominal system voltage. Using the above example; 1 amps x 240 volts x 4 hours = 960 watt-hours divided by 12 DC volts = 80 amp hours.

Same answer. 80 amp hours gone out from the battery in only 4 hours.

Inverters are made with various internal features and many permit external equipment interface. Common internal features are internal battery chargers which can rapidly charge batteries when an AC source such as a generator or utility power is connected to the inverter's INPUT terminals.

Most people only use inverters in a camp to run things that do not already come with a 12 volt cord.

Efficiency Losses:

In all systems there are losses due to such things as voltage losses as the electricity is carried across the wires, batteries and inverters not being 100 percent efficient, and other factors. These efficiency losses vary from component to component, and from system to system and can be as high as 25 percent.

Nominal DC System Voltage

Since solar panels charge your battery and these are both typically low voltage DC items, it's best to decide up-front what your nominal DC voltage will be. This decision is often dictated by the distance between the various components. For example, with solar panels wired at 12 volts charging a 12 volt battery it is difficult to "push" the 12 volts very far, so if the solar array is going to be more than 75 - 100 feet from the batteries it would be advisable to have 24 volt system. As distances is not an issue for most camping situations we can stick with 12 volt systems.

Inverter selection

Inverters are rated in continuous wattage and surge watts. Continuous watts is the total watts the inverter can support indefinitely. So a 400 watt inverter can power up to 400 watts continuously. Surge watts is how much power the inverter can support for a very brief period, usually momentary. So a 400 watt inverter rated at 700 surge watts can handle up to 700 watts momentarily while starting such loads as motors - which usually require more than normal power to get started.

Panel Technologies

Solar panels or modules are categorized into three types, single crystal, multicrystalline and amorphous. These refer to the type of surface that is sandwiched between, usually glass, and a type of thin encapsulant on the back.

The single crystal solar panel is known to be the oldest. The multicrystalline or polycrystalline panels uses chips sliced from single crystals. The amorphous panels are made by sending an aluminium substrate through a vacuum chamber where the silicon gas is blown on. Amorphous panels do not put out per square inch as much as crystalline panels.

They can be almost twice the size for the same output rating. So, if physical size is an issue, as it probably is in most CTs then, the crystalline panels are probably the answer..

You can identify most single crystal panels by their solid one colour solar cells, the multicrystalline by their cells that are chip like and the amorphous which is usually brown and is one complete surface.

For an CT, where space is at a premium the single crystalline can deliver the maximum power in the smallest size, the multicrystalline is not as small as the single crystalline but is close, but has the advantage of usually being a little less expensive. The amorphous panel can take up double the space of a single crystalline.

What Affects Output

The amount of charging power a solar panel puts out is directly proportional to the intensity of the sunlight falling on it. Decrease the level of sunlight to half that of a bright sunny day, and the charging power is reduced by half.

Heat also negatively affects the output of solar electric panels. Contrary to the general public's perception solar electric panels are run off of the sun's light not heat. In fact, the hotter the panel, or more exact the cell gets the less efficient it is. The best place for solar electricity is up in space or in the high mountains where it is clean, clear and cold.

Rating Solar Panels

All solar panels have a detailed energy label on the back. Generally you can find the watts, volts and amps. For a consumer this allows you to compare panels. For the layperson the three pieces of information to pull out are the volts, amps and watts. The watts are described as Nominal Peak Power (P max), the voltage as Peak Power Voltage (Vmp) and the amps as Peak Power Current (Imp). These are the conditions the solar panel can experience when hooked up to the battery.

Quality of Solar Panels

Most solar panels come with 10-20 year warranties. It is extremely difficult to break a solar panel even though most are covered in glass.

What to Look For

Generally look for panels that are 17 volts or higher. This voltage allows for enough voltage drop to be able to hit the batteries at our target of 14.2 volts.

A 17 volt panel, can be also be identified by looking at the front of the solar panel and being able to count 36 cells. As each cell is just under one-half of a volt and these are tied together a 36 cell panel generally means it is at least 17 volts.

Battery Types

Major Battery Types

Batteries are divided in two ways, by application (what they are used for) and construction (how they are built). The major applications are automotive, marine, and deep-cycle. Deep-cycle includes solar electric (PV), backup power, and RV and boat "house" batteries.

The major construction types are **flooded (wet), gelled, and AGM** (Absorbed Glass Mat). AGM batteries are also sometimes called "starved electrolyte" or "dry", because the fibreglass mat is only 95% saturated with Sulphuric acid and there is no excess liquid.

Flooded may be standard, with removable caps, or the so-called "maintenance free" .

Sealed batteries are made with vents that (usually) cannot be removed. The so-called Maintenance Free batteries are also sealed, but are not usually leak proof. Sealed batteries are not totally sealed, as they must allow gas to vent during charging. If overcharged too many times, some of these batteries can lose enough water that they will die before their time.

Gelled are sealed and a few are "valve regulated", which means that a tiny valve keeps a slight positive pressure.

Gelled batteries contain acid that has been "gelled" by the addition of Silica Gel, turning the acid into a solid mass. The advantage of these batteries is that it is impossible to spill acid even if they are broken.

> However, there are several disadvantages. One is that they must be charged at a slower rate to prevent excess gas from damaging the cells. They cannot be fast charged on a conventional automotive charger or they may be permanently damaged.
>
> This is not usually a problem with solar electric systems, but if an auxiliary generator or inverter bulk charger is used, current must be limited to the manufacturers specifications. .

AGM, or Absorbed Glass Mat Batteries uses "Absorbed Glass Mats", or AGM between the plates. This is a very fine fibre Boron-Silicate glass mat. These type of batteries have all the advantages of gelled, but can take much more abuse.

The charging voltages are the same as for any standard battery - no need for any special adjustments or problems with incompatible chargers or charge controls.

AGM's have a very low self-discharge - from 1% to 3% per month is usual. This means that they can sit in storage for much longer periods without charging than standard batteries.

AGM's do not have any liquid to spill. The plates in AGM's are tightly packed and rigidly mounted, and will withstand shock and vibration better than any standard battery. Nearly all AGM batteries are sealed valve regulated (commonly referred to as "VRLA" - Valve Regulated Lead-Acid.

AGM's will cost 2 to 3 times as much as flooded batteries of the same capacity. Their main advantages are no maintenance, completely sealed against fumes, Hydrogen, or leakage, non-spilling even if they are broken, and can survive most freezes. Not everyone needs these features.

Deep Cycle Batteries

Sometimes called "fork lift", "traction" or "stationary" batteries. They are used where power is needed over a longer period of time. They are designed to be "deep cycled", or discharged down as low as 20% of full charge (80% DOD, or Depth of Discharge). hundreds of times.

Deep cycle batteries have much thicker plates than automotive batteries.

What Are the Differences Between Car, Marine Starting and Deep Cycle Batteries?

Car Batteries are specially designed with thinner (.04 inch or 1.02 mm) and more porous plates for a greater surface area to produce the high amps required to start an engine. They need to supply a very large starting current for a very short time. They are engineered for up to 5,000 shallow (to 3%) discharges, which works out to over four engine starts per day.

They should NOT be discharged below 90% State-of-Charge. They use sponge lead and expanded metal grids rather than solid lead. If deep cycled, this sponge will quickly be consumed and fall to the bottom of the cells.

Automotive batteries will generally fail after 30 - 150 deep cycles if deep cycled, while they may last for thousands of cycles in normal starting use (2-5% discharge).

Marine Starting Batteries are a compromise between a car and deep cycle battery and are designed for starting and prolonged discharges at lower amperage that typically consumes between 20% and 50% of the battery's capacity.

Many Marine batteries are usually a "hybrid", and fall between the starting and deep-cycle batteries. In the hybrid, the plates may be composed of Lead sponge, but it is coarser and heavier than that used in starting batteries. "Hybrid" types should not be discharged more than 50%.

Motive and Stationary Deep Cycle Batteries have much thicker (up to .25 inch or 6.35 mm) plates, more lead, and weight more than car batteries the same size. They are normally discharged between 20% and 80% at lower amperage.

Deep cycle batteries will typically outlast two to ten car batteries in a deep cycle application.

It is important to note here that ALL of the batteries commonly used in deep cycle applications are Lead-Acid. This includes the standard flooded (wet) batteries, gelled, and AGM.
Unfortunately, it is often impossible to tell what you are really buying in some of the discount stores or places that specialize in automotive batteries. The popular golf cart battery is generally a "semi" deep cycle - better than any starting battery, better than most marine, but not as good as a true deep cycle solid Lead plate.

Using a deep cycle battery as a starting battery?

There is generally no problem with this, providing that allowance is made for the lower cranking amps compared to a similar size starting battery. As a general rule, if you are going to use a true deep cycle battery also as a starting battery, it should be oversized about 20% compared to the existing or recommended starting battery size to get the same cranking amps.

With modern engines with fuel injection and electronic ignition, it generally takes much less battery power to crank and start them, so raw cranking amps is less important than it used to be. On the other hand, many cars, boats, and RV's are more heavily loaded with power sucking "appliances", such as megawatt stereo systems etc. that are more suited for deep cycle batteries.

How long will a deep cycle battery charge last?

Discharging, like charging, depends on a number of factors such as: the initial state-of-charge, depth-of-discharge, age, capacity of the battery, load and temperature. For a fully charged battery at 70° F (21.1° C), the ampere-hour rating divided by the load in amps will provide the estimated life of that cycle. For example, a new, 72-ampere-hour battery with a 10-amp load should last approximately 7.2 hours. As the battery ages, the capacity is reduced.

Regular battery chargers and deep cycle batteries?

Deep Cycle batteries have a different construction than regular automotive batteries. Be sure and get a Deep Cycle battery charger for them. If you attempt to use a regular automotive battery charger on them, you will boil the water right out of them in about 2 weeks.

Cycles vs. Life

A battery "cycle" is one complete discharge and recharge cycle. It is usually considered to be discharging from 100% to 20%, and then back to 100%.

Battery life is directly related to how deep the battery is cycled each time. If a battery is discharged to 50% every day, it will last about twice as long as if it is cycled to 80% DOD. If cycled only 10% DOD, it will last about 5 times as long as one cycled to 50%.

The most practical number to use is 50% DOD on a regular basis.

This does NOT mean you cannot go to 80% once in a while. It's just that when designing a system when you have some idea of the loads, you should figure on an average DOD of around 50% for the best storage vs. cost factor.

Also, there is an upper limit - a battery that is continually cycled 5% or less will usually not last as long as one cycled down 10%. This happens because at very shallow cycles, the Lead Dioxide tends to build up in clumps on the positive plates rather in an even film.

Battery Life

These are some general (minimum - maximum) typical expectations for batteries if used in deep cycle service:

Starting: 3-12 months
Marine: 1-6 years
Golf cart: 2-6 years
AGM deep cycle: 4-7 years
Gelled deep cycle: 2-5 years

Battery Voltages

All Lead-Acid batteries supply about 2.14 volts per cell (12.6 to 12.8 for a 12 volt battery) when fully charged. Batteries that are stored for long periods will eventually lose all their charge.

In systems that are continually connected to some type charging source, whether it is solar, wind, or an AC powered charger this is seldom a problem.

However, one of the biggest killers of batteries is sitting stored in a partly discharged state for a few months.

A "float" charge should be maintained on the batteries even if they are not used (or, especially if they are not used

Batteries self-discharge faster at higher temperatures. Lifespan can also be seriously reduced at higher temperatures - most manufacturers state this as a 50% loss in life for every 15 degrees F over a 77 degree cell temperature.

Amp-Hour Capacity

All deep cycle batteries are rated in amp-hours. An amp-hour is one amp for one hour, or 10 amps for 1/10 of an hour and so forth. It is amps x hours. If you have something that pulls 20 amps, and you use it for 20 minutes, then the amp-hours used would be 20 (amps) x .333 (hours), or 6.67 AH.

*Most deep cycle batteries are normally rated in number of hours it take to discharge a fully charged battery to 10.5 volts in 20 hours at 80°F (26.7°C), denoted as **"C/20"**.*

This means that it is discharged down to 10.5 volts over a 20 hour period while the total actual amp-hours it supplies is measured.

State of Charge

State of charge, or conversely, the depth of discharge (DOD) can be determined by measuring the voltage and/or the specific gravity of the acid with a hydrometer. This will NOT tell you how good (capacity in AH) the battery condition is - only a sustained load test can do that.

Voltage on a fully charged battery will read 2.12 to 2.15 volts per cell, or 12.7 volts for a 12 volt battery. At 50% the reading will be 2.03 VPC (Volts Per Cell), and at 0% will be 1.75 VPC or less. Specific gravity will be about 1.265 for a fully charged cell, and 1.13 or less for a totally discharged cell.

Many batteries are sealed, and hydrometer reading cannot be taken, so you must rely on voltage.

Battery Charging

Battery charging takes place in 3 basic stages: Bulk, Absorption, and Float.

Bulk Charge - The first stage of 3-stage battery charging. Current is sent to batteries at the maximum safe rate they will accept until voltage rises to near (80-90%) full charge level. Voltages at this stage typically range from 10.5 volts to 15 volts. There is no "correct" voltage for bulk charging, but there may be limits on the maximum current that the battery and/or wiring can take.

Absorption Charge: The 2nd stage of 3-stage battery charging. Voltage remains constant and current gradually tapers off as internal resistance increases during charging. It is during this stage that the charger puts out maximum voltage. Voltages at this stage are typically around 14.2 to 15.5 volts.

Float Charge: The 3rd stage of 3-stage battery charging. After batteries reach full charge, charging voltage is reduced to a lower level (typically 12.8 to 13.2) to reduce gassing and prolong battery life. This is often referred to as a maintenance or trickle charge, since it's main purpose is to keep an already charged battery from discharging.

For long term float service, such as backup power systems that are seldom discharged, the float voltage should be around 13.02 to 13.20 volts.

Battery Charging Voltages and Currents:

Most flooded batteries should be charged at no more than the "C/8" rate for any sustained period. "C/8" is the battery capacity at the 20-hour rate divided by 8. For a 220 AH battery, this would equal 26 Amps. Gelled cells should be charged at no more than the C/20 rate, or 5% of their amp-hour capacity.

AGM batteries can be charged at a higher rate but to avoid cable overheating charging should be at C/4 or less.

Charging at 15.5 volts will give you a 100% charge on Lead-Acid batteries. Once the charging voltage reaches 2.583 volts per cell, charging should stop or be reduced to a trickle charge.

Note that flooded batteries MUST bubble (gas) somewhat to insure a full charge, and to mix the electrolyte.

Float voltage for Lead-Acid batteries should be about 2.15 to 2.23 volts per cell, or about 12.9-13.4 volts for a 12 volt battery. At higher temperatures (over 85 degrees F) this should be reduced to about 2.10 volts per cell.

Chargers:

Most garage and consumer (automotive) type battery chargers are bulk charge only, and have little (if any) voltage regulation. They are fine for a quick boost to low batteries, but not to leave on for long periods.

Among the regulated chargers, there are the voltage regulated ones which keep a constant regulated voltage on the batteries. If these are set to the correct voltages for your batteries, they will keep the batteries charged without damage.

These are sometimes called "taper charge" - as if that is a selling point. What taper charge really means is that as the battery gets charged up, the voltage goes up, so the amps out of the charger goes down.

Charge Controllers

A charge controller is a regulator that goes between the solar panels and the batteries. Regulators for solar systems are designed to keep the batteries charged at peak without overcharging

When using a small solar panel to keep a float (maintenance) charge on a battery (without using a charge controller), choose a panel that will give a maximum output of about 1/300th to 1/1000th of the amp-hour capacity.

<u>Cost and convenience.</u>

Here, the question “How long is a piece of string” really applies. You can spend heaps or little depending on your financial situation and levels of ingenuity and DIY ability.

4x4 forums are full of good ideas and practical solutions to setting yourself up.

Some basic information to go on is:

> **Generators** range from $98 at Bunnings to near $1000 for a good camping sized Honda. I make no comments re value for money, but with a price differential of 10 times, look for big reductions in the price of the dearer units in months to come.
>
> **Dual battery systems** go from DIY of less than $100 (excluding battery) to close to $1000 professionally installed (Including Battery)
>
> **Solar panels** start at $250 for the smallest useful one to close to $900 for a medium sized camping unit. Larger units need a controller at around $50. Solar panels come in 5, 10 up to 120 watts of power. Amps complicates things, but amps are used in the same way as watts. It is better to use amps more than watts because batteries are rated at how many amps they hold. All appliances show how many amps they use in an hour. If we can figure out how many amps of electricity you use we can then match it up to solar panels that will produce that amount of electricity.
>
> **Battery Chargers** for use at home from the real el cheapo of $30 to $300 for 3 stage chargers like those needed for Deep Cycle batteries.

In addition to this is the cost of cabling and connectors. This can be quite high as cabling for fridges is expensive, approaching $2 to $3 a meter to do the job properly.

Add on to this your appliances. Low consumption (1 amp) fluro lights can set you back almost $100 each at camping stores down to normal consumption (1.3 to 1.5 amp) small fluros at $20 in other outlets.

Inverters to run appliances on 240 volts are the same. Prices range from less than $100 to $1,000 plus depending on what you want to run.