Deep Cycle Battery FAQ

What is a "Flooded Lead Acid" battery

Flooded lead acid (wet cell) batteries are one of the most common types of battery for deep cycle applications. The major difference between the wet type of battery and the sealed kind is that the end user is able to replace water lost through gassing via the vent caps in the top of the battery.

The flooded battery has been around for a very long time but remains popular because it has a good balance between price and performance. A gel or AGM cell battery is generally somewhere around twice the price per amp hour that you would find in a flooded battery.

Flooded batteries do require a lot more maintenance than their sealed lead acid counterparts, because the batteries are not recombinant the water is lost though the top of the vent caps while charging. Replacing this lost water can sometimes be an onerous task but it is a necessary one to get the most out of your battery.

Types of Sealed Batteries (VRLA's)

Sealed Lead Acid batteries are often referred to as being "maintenance free" or valve regulated. In a sealed lead acid battery the unit is sealed, meaning that water loss is kept to a bare minimum and also that you needn't put any water into the battery. Most of the sealed VRLA batteries are *recombinant* which essentially means that the water lost through the venting of hydrogen and oxygen in a flooded battery is

The most common types of Sealed Lead Acid batteries that we carry are the AGM (Absorbed Glass Mat) batteries; another is the GEL type of battery.

AGM batteries have a very fine Boron-Silicate glass mat in between the plates inside the battery. The mats are about 95% filled up with electrolytes rather than completely saturated. The huge advantage of this type of battery is that they can be operated in almost any orientation and will even function underwater. They will also never leak, even if punctured.

The Gel cells have the electrolyte stored in a gel form, this also won't spill out even if the batteries are broken and also prevents the stratification that other battery types can have. Gel cells however do have some limitations; they take a slower charge than a comparable sized AGM battery and also if they are overcharged voids can form in the gel which permanently reduces the battery capacity.

For deep cycle applications however the Sealed Lead Acid type of battery can be a good deal more expensive than a comparable Flooded Lead Acid battery. However there are times when a sealed battery will better meet your needs than a flooded one. Particularly marine applications where stability isn't always a given, and ventilated spaces are hard to come by seem well tailored to a sealed lead acid battery. One other advantage that AGM and Gel batteries have over flooded types is the low self discharge rate. Where a Flooded battery will lose about 13% of its charge in a month a Gel or AGM will lose 1% -3%.

What are the differences between a starting and deep cycle battery?

Generally speaking there are two different types of lead acid battery, Starting and Deep Cycle. If a starting battery is routinely deep cycled (discharged below 20%-50% of max capacity) it will generally fail after 30-150 cycles. The same starting battery will last for thousands of cycles if it is just used normally (2% - 5% discharge).

A starting battery is generally designed to start some form of internal combustion engine (car, truck, boat etc). In a starting battery you will find more lead plates, thinner and often made of a lead "sponge" similar looking to a foam sponge. This sort of arrangement means that the plates have much more surface are in the solution than a Deep Cycle battery and allow them to draw larger currents much quicker than a Deep Cycle battery.

A deep cycle battery on the other hand has much thicker plates and they are solid, not sponge. These thicker plates have less surface area and thus less of the instant power that a starting battery needs. They are designed to be discharged down to 20% of their maximum charge repetitively. The thicker lead plates allow for this as they are much sturdier than their sponge counterparts.

Cold Cranking Amps (CCA) is an indicator of the amount of current a battery can deliver for 30 seconds at zero degrees Fahrenheit without dropping below a specified cutoff voltage (normally 10.5 volts). The cranking amps a battery can produce changes with temperature. The warmer it is the more Cranking Amps a battery will produce.

You can use a Deep Cycle battery as a starting battery provided that you take into account the lower CCA of a Deep Cycle battery. As a rule of thumb it's a good idea to upsize the battery by about 20% to deliver the same amount of cranking amps from a deep cycle battery. Also the self discharge rate of Sealed batteries is a lot less than flooded lead acid types.

How long will my battery last?

How long a battery will last depends hugely upon the way it is used and how well the battery is maintained. Both overcharging and undercharging will have serious adverse effects on the lifespan of a deep cycle battery.

In particular you can seriously shorten the lifespan of a battery if it is used in a deep cycle application that it was not designed for. An example of this would if you were to use an automotive starting battery as a deep cycle battery.

General expectations for batteries if deep cycled (these are just approximate guidelines):

Starting battery (Automotive battery etc) : 3-13 months
Marine Battery : 1-6 years
AGM Deep cycle: 4-7 years

Gel Cell Deep Cycle: 2-5 years
Flooded Lead Acid Deep Cycle Battery (L16-RE etc): 4-8 years

The main things that you can do to ensure you get the maximum value out of your deep cycle batteries are to keep them maintained. This means keeping them watered to the appropriate level, trying to keep from discharging them more than 50% of their total capacity and having appropriate charging systems in place.

The charging is of special importance because both over and under charging will severely limit the life of your batteries, also if your batteries will see an extended period without being used you should ensure they are routinely checked, cleaned and fully charged before being stored. Also in some cases it can be a good idea to put your batteries on a maintenance charge over long periods of disuse.

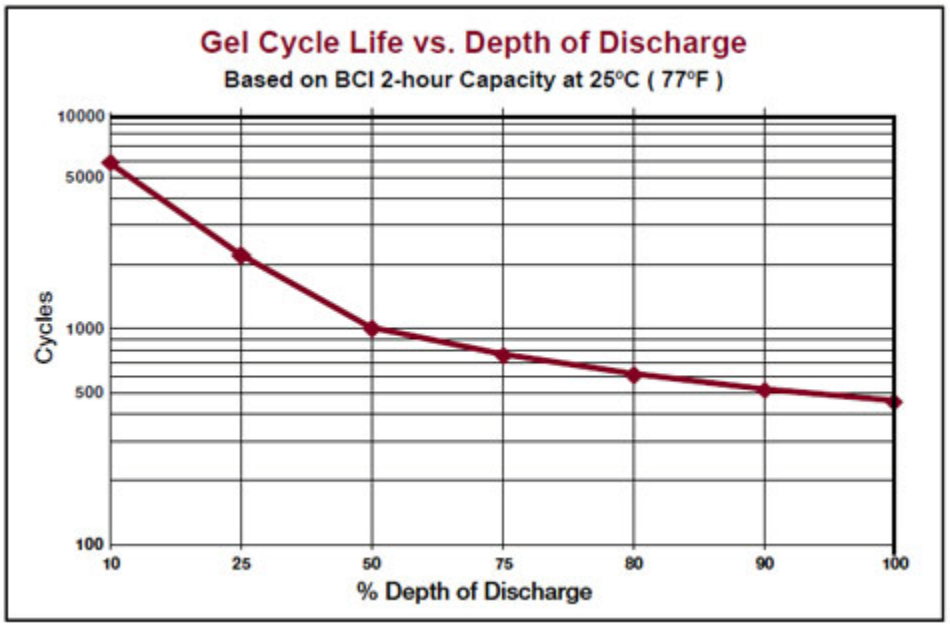
Battery Cycles vs. Battery Lifetime?

Often the lifespan you can expect to get out of your battery is referred to in terms of "cycles". A battery cycle is one complete discharge and recharge cycle. The discharge state of a battery is often measured in Depth of Discharge (DOD). This refers to how far down the battery has been taken, for instance a battery that has 25% of its capacity remaining would be said to be at 75% DOD.

The lifetime of a battery is directly related to the depth of the discharge that it regularly experiences. Lead acid batteries are fickle things. If you subject a deep cycle battery to 80% DOD on a regular basis you will get roughly half the life out of your battery than if you were to cycle it to 50% DOD.

While this doesn't mean that you can't go down to 80% DOD you should generally try to design your battery banks to allow for cycling at around 50%.

Conversely there is also an upper limit on the DOD of a battery, usually a battery that is only regularly cycled down to 5% or less will not last as long as a battery cycled to 10% or more. This is because on smaller cycles the Lead Dioxide can clump up around the positive plates. On heavier discharges this would be more of an even film.



Effect of DOD on lifetime of Trojan Gel Cell battery

What does Equalizing my batteries entail and when should I do it?

Equalizing a lead acid battery is the practice of applying a controlled overcharge in order to prolong the battery life, restore lost capacity and to make the battery more efficient.

Batteries require equalization because as a battery is cycled (discharged and recharged) a small amount of lead sulfate remains on the lead plates. When you use a three stage charge the degree of sulfation is lessened, but not entirely eliminated. If this sulfate is left on the lead plates it will crystallize, once enough of these crystals have built up on the lead plates they can lead to lowered capacity and lower the amount of power the battery can produce.

Also over the lifetime of a battery the electrolyte solution can tend to stratify, forming layers inside the battery. This can cause the acid near the top of the cell to be more dilute than the acid at the bottom.

An equalizing charge is essentially a controlled overcharging of the batteries which will allow the sulfate on the lead plates to recombine into sulfuric acid, it will also break loose any crystallized sulfate on the plates which will then fall to the bottom of the battery.

It's always a good idea to not fill your batteries before you equalize, the electrolyte will expand during equalization and if the batteries are too full they could overflow. There should be enough liquid to cover the plates and not much more.

Below is a table from Trojan batteries website detailing their recommended charge levels and durations:

Trojan Batteries recommended charger voltage settings:					
	System Voltage				
Charger Voltage Setting	6V	12V	24V	36V	48V
Daily Charge	7.4	14.8	29.6	44.4	59.2
Float	6.6	13.2	26.4	39.6	52.8
Equalize	**7.8**	**15.5**	**31.0**	**46.5**	**62.0**

Important things to note before equalizing your batteries:

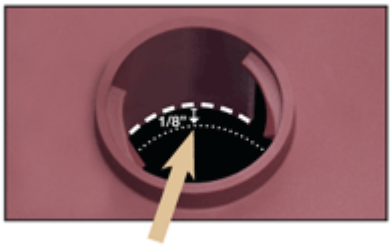
- Any DC loads on the batteries should be turned off, the greater than normal voltage that occurs during equalization can cause damage to anything attached.
- Leave the caps on the cells, these caps are vented and will prevent your electrolyte splattering onto the top of the battery. Sometimes laying a paper towel over the tops of the batteries can be a wise precaution also.
- If a battery starts to "spit" acid stop the charging process immediately
- Batteries should be fully charged and at room temperature before you equalize

Equalizing steps:

1. Make sure the batteries are fully charged, at an even temperature and are flooded acid.
2. Take off any loads from the batteries
3. Connect your charger
4. Set the charger for the correct voltage
5. Start to charge your batteries
6. The batteries should begin gassing and bubbling
7. Take specific gravity readings every hour or so
8. When the gravity values no longer rise during the gassing stage the equalization is complete

How often should I refill my batteries (or do I even need to)?

Flooded batteries have to be watered periodically to maintain their performance and increase their longevity. As the chemical reactions take place some of the water is lost as gas from the vent caps. This means that the acid in the battery will eventually get below the level of the lead plates. Luckily as it is just water that is being lost (hydrogen and oxygen) all that has to go back in is pure water.

Trojan Battery fill chart	
For Fully charged Trojan Deep Cycle batteries.	For fully charged Trojan Deep Cycle Batteries
	
Add water to 1/8" below bottom of the vent well.	Add water to the maximum water level indicator.

The frequency with which you'll need to add water to your batteries will vary depending on the temperature and how often the batteries are cycled (charged and discharged).

More frequent cycling or higher temperatures will mean more frequent watering. It's generally a good idea to top off your batteries every month or so at first until you get an idea of how thirsty your batteries are.

It is always best to use distilled or deionized water when refilling your batteries. Normal tap water can contain minerals and chemicals that can decrease battery capacity and increase the self discharge rate of the battery.

If your batteries are under heavy use or in are in a spectacularly awkward position you may find it advantageous to look into a watering system for your batteries. These snap into place over the vent holes on the battery, connected by a hose. When you need to fill your battery you just attach a water supply and the whole process is done in a few minutes with no risk of spillage. It's much better on time and clothing than the normal method.

What is Specific Gravity and how should I check it?

Specific gravity is used to check the state of charge of a battery, essentially it's the ratio of a the weight of a solution to the weight of an equal volume of water. Testing the specific gravity of a cell is done using a hydrometer, the best of these automatically compensate for temperature.

As the ratio of water to sulphuric acid inside the battery changes with activity the density of the electrolyte also changes, this is what the hydrometer measures.

Another test that should be performed along with the Specific Gravity tests is looking at the Open Circuit Voltage of your battery.

These are the steps that Trojan Battery recommends for performing specific gravity tests on their batteries:

Specific Gravity Test
(Flooded batteries only)

1. Do not add water at this time.
2. Fill and drain the hydrometer 2 to 4 times before pulling out a sample.
3. There should be enough sample electrolyte in the hydrometer to completely support the float.
4. Take a reading, record it, and return the electrolyte back to the cell.
5. To check another cell, repeat the 3 steps above.
6. Check all cells in the battery.
7. Replace the vent caps and wipe off any electrolyte that might have been spilled.
8. Correct the readings to 80o F:

    Add .004 to readings for every 10o above 80o F

    Subtract .004 for every 10o below 80o F.

9. Compare the readings.
10. Check the state of charge using the table below

The readings should be at or above the factory specification of 1.277 +/- .007. If any specific gravity readings register low, then follow the steps below.

1. Check and record voltage level(s).
2. Put battery(s) on a complete charge.
3. Take specific gravity readings again.

If any specific gravity readings still register low then follow the steps below.
1. Check voltage level(s).
2. Perform equalization charge. Refer to the Equalizing section for the proper procedure.
3. Take specific gravity readings again.

If any specific gravity reading still registers lower than the factory specification of 1.277+/- .007 then one or more of the following conditions may exist:

1. The battery is old and approaching the end of its life.

2. The battery was left in a state of discharge too long.
3. Electrolyte was lost due to spillage or overflow.
4. A weak or bad cell is developing.
5. Battery was watered excessively previous to testing.

Batteries in conditions 1 - 4 should be taken to a specialist for further evaluation or retired from service.

II. Open-Circuit Voltage Test

For accurate voltage readings, batteries must remain idle (no charging, no discharging) for at least 6 hrs, preferably 24 hrs.

1. Disconnect all loads from the batteries.
2. Measure the voltage using a DC voltmeter.
3. Check the state of charge with Table 1.
4. Charge the battery if it registers 0% to 70% charged.

If battery registers below the Table 1 values, the following conditions may exist:

1. The battery was left in a state of discharge too long.
2. The battery has a bad cell.

Batteries in these conditions should be taken to a specialist for further evaluation or retired from service.

TABLE 1. State of charge as related to specific gravity and open circuit voltage

Percentage of Charge	Specific Gravity Corrected to 80o F	Open-Circuit Voltage					
		6V	8V	12V	24V	36V	48V
100	1.277	6.37	8.49	12.73	25.46	38.20	50.93
90	1.258	6.31	8.41	12.62	25.24	37.85	50.47
80	1.238	6.25	8.33	12.50	25.00	37.49	49.99
70	1.217	6.19	8.25	12.37	24.74	37.12	49.49
60	1.195	6.12	8.16	12.24	24.48	36.72	48.96
50	1.172	6.05	8.07	12.10	24.20	36.31	48.41
40	1.148	5.98	7.97	11.96	23.92	35.87	47.83
30	1.124	5.91	7.88	11.81	23.63	35.44	47.26
20	1.098	5.83	7.77	11.66	23.32	34.97	46.63
10	1.073	5.75	7.67	11.51	23.02	34.52	46.03

Charging a battery.

When charging a lead acid battery the charging takes place in 3 stages. Bulk, Absorption and Float, this is why some chargers are referred to as being 3-Stage.

The Bulk Charge:

This is the first stage of 3-stage battery charging. The charger sends the current through to the cells at the maximum safe voltage they can handle. There is no correct voltage on this but generally it ranges from 10.5 to 15 or so volts. This stage charges the battery up to somewhere near 80% to 90% of its capacity.

Absorption Charge:

During this second stage of the charging cycle the voltage remains constant then gradually lowers as the internal resistance in the battery increases as it charges. This is the stage that the charger will generally put out the maximum voltage that it can and is generally around 14.2 to 15.5 volts.

Float Charge:

After the battery reaches its full charge during the absorption phase of charging the charging voltage drops down to around 12.8 to 13.2 volts in order to reduce gassing and prolong the life of the battery. This stage is also sometimes referred to as a "Maintenance Charge" which is left on the whole time the battery is not being used so as to ensure that the battery is fully charged and able to function a tit's full capacity when it is needed.

Chargers:

Not all chargers are created equal; there is a huge difference between what a good quality three stage charger will do for your battery and what a cheap charger will do to your battery if used wrongly.

The best chargers are 3-stage and have various safety features on them, such as not allowing current to flow till they detect a battery is connected and connected correctly. Also they may be fan cooled and have features like automatic temperature correction, short circuit protection and so forth.

The other type of battery charger is generally one that will have none of the built in safety features that are mentioned above and will not automatically shut off or lower the voltage after the battery has gotten past the bulk charge stage. This makes it possible to do significant damage to your battery even to the point of a critical failure if this sort of charger is left unattended.

Always make sure you have read the manual and are following proper precautions before charging your deep cycle batteries.

You can get a fairly good idea of how charged your batteries are by testing the voltage regularly:

State of Charge	12 Volt battery	Volts per Cell

100%	12.7	2.12
90%	12.5	2.08
80%	12.42	2.07
70%	12.32	2.05
60%	12.20	2.03
50%	12.06	2.01
40%	11.9	1.98
30%	11.75	1.96
20%	11.58	1.93
10%	11.31	1.89
0	10.5	1.75

To get a more specific reading on state of charge you'll need to take specific gravity readings.

What is an "amp hour" and how much capacity do I need?

Battery capacity is rated in amp-hours. This is a measure of how much amperage can be drawn from a fully charged battery over time until it is discharged (for a 12 volt battery this is when it reaches 10.5v). Then the amps are multiplied by the amount of time taken to get the Ah rating.

As an example of this, if you had a device that pulled 25 amps and you used it for 30 minutes then the amp-hours used up would be 25(amps) x 0.5(hours) = 12.5 amp-hours.

The standard and most widely accepted rating period for deep cycle batteries is 20 hours. This means that the battery was discharged down to 10.5 volts over 20 hours while measuring the total amp hours it supplies.

Sometimes however the time period can differ, in some circumstances knowing the 6 hour amp rating may be more useful and in others the 100 amp hour rating may be used. Due to something called the Peukert effect a battery gives higher amp hours when it is discharged over a longer time period. For instance the rated Capacity for the Trojan T105-RE is 225 at 20 hours and 250 at 100 hours.

How does temperature affect my batteries?

The capacity and life expectancy of a lead acid battery will vary depending on the temperatures that it operates in. Battery capacity increases in hotter temperatures though battery life decreases. Also in the colder temperatures the battery will have less capacity but it will last longer. At freezing battery capacity is about 20% lower, at 122 degrees F battery capacity is around 12% higher.

The charging voltage for a battery will also vary from 2.74 volts per cell (16.4 for a 12v battery) at -40c to 2.3 volts per cell (13.8 on a 12 volt battery) at 50c. Some charge controllers have this temperature correction built in.

Does my deep cycle battery suffer from memory effect?

Lead Acid Batteries do not have a memory, in fact completely discharging lead acid batteries will lead to a dramatic shortening of the lifespan of the battery.