Guide to LiFePO4 (Lithium) Technology Batteries

This is intended as a light-bite guide to Lithium batteries for motorcyclists, it explains only the most pertinent points with a smattering of technical detail to help illustrate the principles and differences of lithium batteries.

Lithium iron phosphate batteries, often identified as ***LiFePO4*** are a distinct type of lithium-ion battery. When buying a battery for your motorcycle you must make sure you are getting a LiFePO4 type and not any other variation or type of Lithium-ion battery. Note the difference in spelling of 'ion' and 'iron', its not a typo its a difference in chemical make up of the cells. LiFePO4 cells are very safe and can withstand a much greater degree of over-charging and abuse than all other types of lithium cell.

The technical bit is that the explosive reaction of LiFePO4 cell is 90 Joules of energy released explosively per gram of lithium, where as in the case of Lithium-ion its 1600 Joules per gram when subjected to over-charging. I know which battery I'd prefer to be sitting a couple of inches above if a charging fault developed whilst riding. If you heard of some cell phones catching fire, you'll not be surprised to learn that it only happened to the more reactive lithium-ion batteries. Lithium-ion is more powerful but is likely to burst in to flame if there is any degree of incorrect charging.

Be very cautious of sellers insisting that charge voltages are never exceeded, even by a small amount, these batteries may be the more reactive (dangerous) type or may have no charging protection.

LiFePO4 offers many advantages over traditional lead acid batteries. It's weight is the most obvious. Lead acid cells typically supply 44 amp-hours per kilo of metal lead where as LiFePO4 gives in excess of 145amp-hours per kilo of Lithium. In theory a 44 amp-hour lead acid battery will weigh a kilo, in practise it will be significantly more due to inefficiencies and the extra parts needed to form a battery assembly. A lithium battery will weigh well under a third of this (0.3 Kg). The different chemical make-up of the lithium cell means that you don't require any old style construction methods of traditional lead acid cell, thus further reducing the weight of the battery. In practice because of the very high energy density of lithium cells, manufacturers will use an even smaller cell to further reduce the battery weight, however this is at the expense of the length of time the power is available to start the engine.

Its important to note that a lithium motorcycle battery will give only a very limited number of start attempts compared to a lead acid battery.

Charging Information

LiFePO4 Cell Voltages	
Nominal cell voltage	3.2V
Peak cell voltage	3.65V
Absolute over-charge voltage	4.2V
Absolute discharge voltage*	2.0V
Charging CV to 95%	3.5V
Charging CV to 100%	3.65

* Never exceed; bringing the voltage lower will permanently damage the cell.

To bring a LiFePO4 battery to 100% state of charge (SOC) requires two step charging. The first step used is called constant current charging (CC) where a fixed current is supplied and the voltage is allowed to 'float' until the cell voltages reaches 3.65 volts. At this point the cell is only at 60% charge. From this point a constant voltage (CV) is needed. Now the charger's voltage is fixed

at 3.65V per cell but the current is supplied at a rate the cell can accept. As the cell reaches 100% charge the current is reduced in a uniform taper but the charger voltage remains fixed 3.65V. This type of charging schedule is only provided by Lithium specific chargers and is the only way to bring a lithium battery to 100% charge.

Cell Balance or Imbalance Protection

You may have heard these terms applied to Lithium batteries, but what does it really mean? Your battery is made up of a number of cells connected in series to achieve the correct battery voltage. Lead acid batteries have cells that give about 2 volts each, so six are connected together to give a 12 volt battery. Each of these cells 'self balance' when they are being charged so that all the cells continue to charge until they are all at the same voltage.

Lithium batteries are different, when one cell becomes fully charged it stops accepting a charge and in effect "switches off", blocking the charge current to the rest of the battery so it cannot charge up. Matching the cells so they have the exact same voltage is impractical (although manufacturer's of high quality batteries will seek to ensure all the separate cells are within 0.001V of each other). However the situation will always arise where the battery will only charge to the level of one cell.

To overcome this a 'cell balancing' circuit is needed. This is basically a circuit board inside the battery that shares the charge current to each one of the cells separately. They will also have a thermal cut out to stop charging if the cells get too hot. Every lithium battery needs this, its not a special feature, its a necessity.

Do not confuse cell balance and thermal protection as full battery protection. This is simply the minimum equipment needed to allow a lithium battery to be charged.

Full Battery Protection

Its commonly known that over charging is bad for any type of battery, more so with Lithium batteries. What is less known its that your expensive Lithium cell becomes scrap if you discharge it too far. There is no way to recover it once this has happened and this will not be covered by the warranty. Batteries returned with low voltage will be refused a warranty replacement. You may be trying to start the engine, using the headlamp without the engine running or just have forgotten and left the ignition switched on, but if the battery voltage drops below 8 volts (for a 12V battery) the battery becomes scrap with no hope of recovering it. This is very different from a lead acid battery where a good charger can recover a badly discharged battery.

Full battery protection both switches off the battery before it reaches critical discharge, saving the battery from permanent damage and blocks overcharging current. If the discharge protection kicks in, simply connect the battery to any motorcycle type battery charger and let it recharge, it will come back to life with no ill effects. Conversely if the battery is over charged a special circuit dissipates un-needed power instead of dumping it to the battery's cells.

Most Lithium batteries only have cell imbalance and thermal protection.

The Motobatt "HP" range has over-charge & discharge protection.

Forced charging

Because LiFePO4 is so tolerant of over charging, force charging to a 95% SOC is possible in a very short time and without damaging the battery or shortening its life - providing its done with the correct type of Lithium battery charger. Normal lead acid battery chargers can also be used but will never fully charge a lithium battery.

Problems occur where you leave a lead acid charger connected for more time than required to get the battery charged enough so you can use it again. The 'dumb' type of lead acid charger IE ones you plug in and they just keep on charging, needing to be switched off when the battery is charged

(this includes trickle chargers) will charge a lithium cell but problems will occur if you leave them connected for any longer than the battery needs. All Lithium batteries react badly, often in a very spectacular fashion if excessively charged, even with trickle chargers - so remember to switch the charger off as soon as the battery is charged. Additionally intelligent lead acid battery chargers have a maintenance feature known as the 'float charge' stage where they reduce their voltage to keep lead acid cells healthy. This voltage is far below the level that its possible to charge a lithium battery and so they could cause its own set of problems if connected for prolonged periods. Trickle chargers and Intelligent lead/acid chargers can be used to charge a lithium battery however they will not bring the battery to 100% charge and must not be left connected any longer than needed.

To properly maintain your lithium battery you ***must*** use the correct Lithium charger for the battery. The correct lithium charger can be safely left connected if it is of the 'maintenance' type. Maintaining lithium batteries at 100% charge is recommended when you are not using your motorcycle.

Effects of temperature

Lithium batteries are far more sensitive to temperature than lead acid batteries. While increasing the temperature of a lithium battery will improve its output by as much as 10%, conversely when the temperature drops below 10 degrees C it's performance starts to drop dramatically.

Note that heating any battery is extremely dangerous and must be avoided.

Below zero degrees C lithium batteries may not accept a charge at all. The Motobatt HP range will exercise the cells to keep them warm, reducing this effect although the battery may not give as much power.

Regulator Rectifiers

Your regulator rectifier will be designed for lead acid batteries. Using a lithium battery is very likely to invalidate any warranty on it, unless its manufacturer specifically offers a warranty on Lithium battery use. Remember your battery must accept the vehicle's charging output. It is not the case that your vehicle must accept a different type of battery to the one the manufacturer specifies. Any replacement regulator rectifier will be designed to suit the type of battery specified in the bike's parts list, normally this is a sealed, AGM or wet type of lead acid battery.

In Conclusion

Its vitally important to ensure you are getting a LiFePO4 battery and not any other type of Lithium battery. These safely offer large amounts of power for their weight and can accept some over-charging and abuse. However Lithium motorcycle batteries available today do not supply power for long periods and if you discharge them too far the battery can be permanently damaged. Also if you ride in Winter you may experience reduced battery performance.

To avoid many of the problems associated with over charging and low voltage shut down you should choose a fully protected battery. These features are distinctly different from basic cell imbalance and thermal protective devices.

A worthwhile consideration is adding a regulator saver, connected to the battery in case the Lithium battery's protective circuit shuts off the battery while the engine is running. Most regulator/rectifiers will fail instantly if the connection to the battery is lost while the generator is producing AC current. A regulator saver only provides a reference voltage if a Lithium battery shuts down. The cause of the shut down must be investigated and the problem fixed without delay. Regulator savers do not stop other faults damaging the regulator/rectifier.

You will also require a proper Lithium battery charger to maintain your Lithium battery, so factor this cost in when considering a Lithium battery LiFePO4 batteries are a new technology for motorcycles and offer advantages in terms of performance and weight but disadvantages in that they are effected by temperature, being discharged too much and require their own type of battery charger.