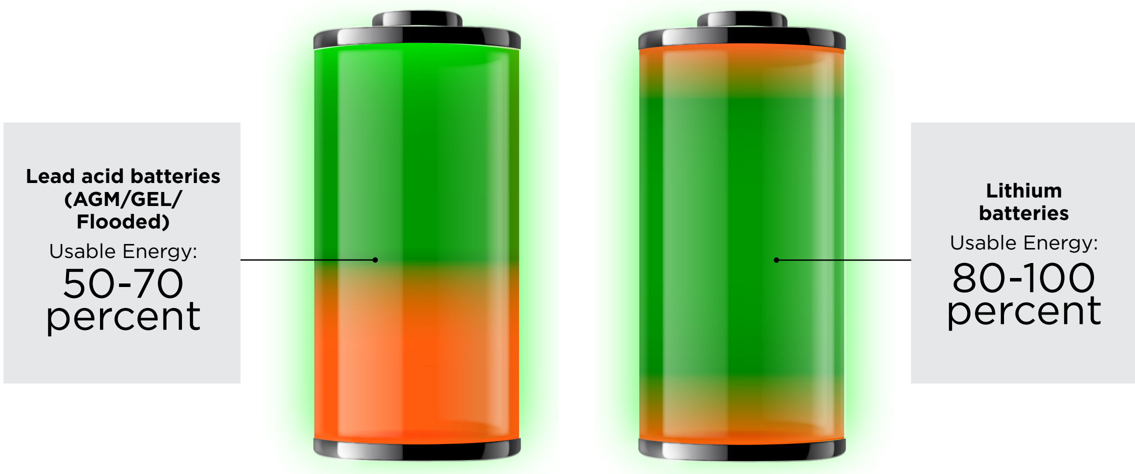
WHY ARE LITHIUM IRON-PHOSPHATE BATTERIES SO GREAT?

BY JEFF COTE



There has been a lot of attention around electric cars lately and the majority of the high-end manufacturers are using lithium iron-phosphate (LiFePO4 or LFP) batteries. Some boat manufacturers are choosing lithium but it is not mainstream. Today we are going to look at why it may be time to consider lithium.

Lithium is a highly reactive alkali metal element first discovered in 1817. The concept of a lithium-ion battery was initially introduced in the 1970s and became far more popular in the 1990s. Lithium technology became a favourite for powering small electronics, like laptops, but soon earned a bad reputation. Those batteries used a lithium-cobalt-oxide chemistry, which is prone to thermal runaway if the battery is overcharged. This was the main reason lithium was not used to create large battery banks. In the mid 1990s a new formula emerged using lithium-iron-phosphate which has a lower energy density and is non-combustible.

Lithium iron-phosphate (LFP) battery technology is inherently safer than all other lithium battery chemistries. The included battery monitoring system removes the source of a fault and the battery stabilizes to a safe condition immediately. These batteries are controlled internally by electronic circuitry that keeps the cells in balance under all conditions.

In comparison with typical lead acid batteries, LFP batteries are up to 70 percent lighter for equivalent usable battery capacity, charge faster, have a higher cycle life and an incredibly accurate state of charge indicator. Let's take a closer look.

DEPTH OF DISCHARGE LFP batteries have often been dismissed because of the high cost in comparison to AGM batteries. This argument was based on amp-hours but if you look at usable battery capacity, i.e. range between acceptable depth of discharge and end of bulk charging, a standard AGM battery has 50 percent of usable capacity, a Firefly Oasis AGM battery has 60 percent of usable capacity, and a LFP has 80 percent of usable capacity.

Let's take a look at the usable energy and cost. We will take two Victron* batteries and compare the usable energy for a mid-size boat:

1 X VICTRON LITHIUM = 24 VDC @ 180 AMP-HOURS
This 26.4 V battery consists of eight 3.3 VDC cells connected in series for a 180 amp-hours rating. The available energy is 26.4 X 180 = 4.75kWh. The usable energy is 26.4 X 180 X 0.80 = **3.8 kWh.**

2 X VICTRON AGM 12V = 24 VDC @ 220 AMP-HOURS
The nominal voltage of the lead-acid cell is 2.0 V/cell. Each 12 V battery consists of six cells connected in series with a 220 amp-hour rating. Connecting 2 x 12 V 220 amp-hour batteries in series to give 24V and 220 Ah, the available energy is 24.0 x 220 = 5.28 kWh. Usable energy is 24 x 220 x 0.50 = **2.64 kWh**.

The cost for a 24 VDC 180 amp-hour Victron lithium battery is $7,400 or $51 per usable amp-hour and the cost for a 24 VDC 220 amp-hour Victron AGM battery bank (2 X 12V in series) is $1,400 or $13 per usable amp-hour. Therefore, the cost of lithium is four times more expensive.

CHARGING A lead acid battery has three stages of charging: bulk, absorption and float. A LFP has essentially two stages: bulk and float. Lead acid batteries can take about 25 percent to 40 percent of capacity as a charge rate, LFP can take up to 300 percent of capacity. Basically, this means that the limiting factor for charging a LFP battery is the charge source and not the battery itself. For instance, a 200 amp-hour flooded lead acid battery could only take a theoretical maximum charge rate of 50 amps (25 percent of 200 amp-hours), an AGM battery a theoretical maximum charge rate of 80 amps (40 percent of 200 amp-hours). But a LFP battery could take 600 amps (300 percent of 200 amp-hours).

When the alternator or charger sends energy to a LFP battery, it generally charges as fast as the alternator or charger can generate output. And even if you don't manage to top off the battery to 100 percent, unlike a traditional lead acid battery, the LFP battery will not be damaged. LFP batteries are more efficient than traditional lead acid batteries allowing for shorter, faster charging times. This means less generator run time.

WEIGHT Another key consideration is weight. We are seeing more and more boaters adding larger battery banks to keep up with the increased loads from refrigeration, navigation equipment, entertainment systems, inverters and so on. A 48Vdc/800 amp-hour AGM battery weighs 1,360 kilograms whereas a 48Vdc/400Ah LFP battery weighs 336 kilograms, that is four times lighter. Mastervolt recently introduced an entry-level 12V LFP battery at just 30 percent of the weight and volume of its lead acid counterpart.

CYCLES At 80 percent depth of discharge, a LFP battery has 2,000 to 5,000 cycles, whereas a flooded lead acid has less then 10 percent of that.

LFP batteries have a higher voltage output and maintain mostly a consistent delivery of voltage power throughout discharge. Lead acid voltage drops consistently throughout the discharge cycle. This means that sensitive electronics or electrical equipment get the benefit of steady voltage as the battery is drained allowing the equipment to run smoothly.

SUMMARY LFP batteries with a top quality BMS require very little maintenance and do not need to be stored upright or in a vented compartment. LFP batteries use a much cleaner technology and are safer for the environment. They deliver higher quality performance in a safer, longer-lasting package. Most people believe that a LFP battery will often outlive the boat.

Sources: *Calculations supplied by John Rushworth and Victron Energy Corp.

Jeff Cote is a systems design engineer and owner of Pacific Yacht Systems, a full-service shop delivering marine electrical and navigation solutions for recreational boats. Visit their website and blog for info and articles on marine electrical systems, projects and more. pysystems.ca