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The 'black art' of batteries


A Genie Z-60/37 FE battery pack


Samsung Galaxy Note 7 battery malfunction

You would think that with technology dating back almost 160 years everyone would have a very good understanding and be able to use lead acid batteries correctly? Unfortunately far too many still do not understand the basic requirements - particularly charging and maintenance. And with the growth of Gel, AGM (Absorbed Glass Mat) and more recently lithium, the already 'black art' of batteries has become even more confusing.

Fortunately the traditional lead acid battery is still the main source of power for aerial work platforms, primarily because it offers a better battery life than Gel or AGM batteries, is widely available and considerably cheaper. The downside is that the lead acid battery requires more maintenance and can deteriorate very quickly if not looked after. And it has to be said, equipment users are generally not very good at looking after what is a very expensive consumable, which if looked after correctly should last five years but can all too often be just a year or less if not.

Lithium the solution?

The general awareness of the lithium ion battery - invented in the 1980s and commercialised in the 1990s - continues to grow, possibly to a point where it may be better known than the lead acid battery. Of course high profile products that have hit the news - Tesla's electric cars and its world's largest 100MW lithium ion mega-battery in South Australia - have helped the general public become more familiar with the technology, almost to the point of people thinking the lithium battery will mean the end of the combustion engine. In the lifting market we have seen the growth of lithium batteries powering spider lifts, hybrid utility platforms and small industrial cranes etc.

However lithium ion batteries have their own safety problems, with cells becoming thermally volatile if abused or used outside their safe operating area. In 2013 at least four Boeing 787 Dreamliner's were grounded due to battery fires. Three years later seven hoverboard brands with half a million boards and 2.7 million Samsung Galaxy Note 7 phones were recalled because of overheating problems.

These are all instances where lithium batteries were assembled or operated in conflict with the suggested safety practices. All forms of energy storage have some inherent risks, particularly when large amounts of energy is contained in a small space. Lithium-ion batteries are no different, but as the technology matures, the risks are becoming better understood and can therefore be properly managed. To avoid this all lithium batteries require a battery management system which adds potential complexity and cost.

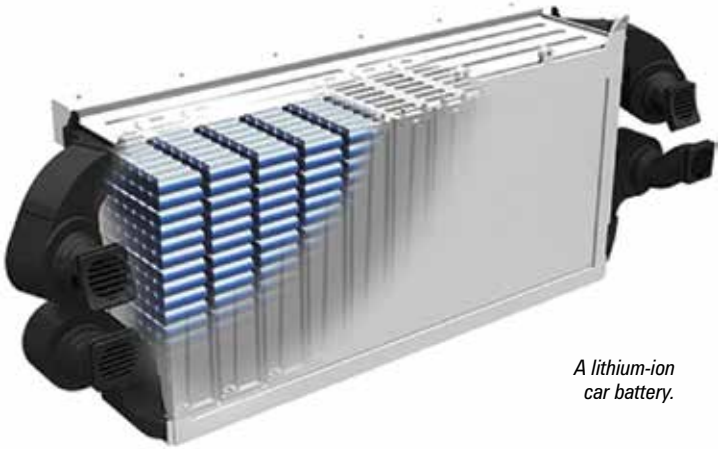
Lithium vs lead-acid

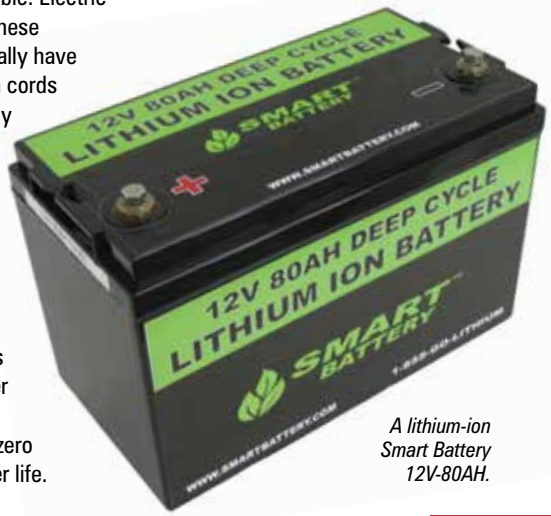
When designing equipment, the power source is often the bottleneck in terms of size, weight, and cost, as well as for run time and reliability.

Combustion engines provide high power and quick refuelling, but maintenance, noise and environmental issues are becoming increasingly unacceptable. Electric motors solve most of these issues, though historically have inconvenient extension cords or are weighed down by large battery packs.

Many equipment manufacturers are looking to lithium-ion batteries as a solution to improve run times, reduce maintenance and operating costs, as well as providing lighter weight, higher power, faster charging times, zero maintenance and longer life. However, the solution is not right for every application and can present challenges such as cost, complexity and we have already mentioned, safety.

In our battery feature last year we explained the types and workings of the lead acid battery and its variants, as well as pointing out the common problems particularly size, weight, and limited life and energy storage. The lithium-ion battery is the new kid on the block and the technology has rapidly evolved and improved. Like lead acid, lithium batteries are constructed with pairs of electrodes, but these are typically thin films of graphite - the negative - and metal oxides - the positive - pasted on copper and aluminium foils, insulated from each other by a thin plastic separator and stacked or wound. Lithium-ion batteries are always sealed, whether in rigid metal or flexible plastic cell packaging which prevents leaking,


A lithium-ion car battery.



A lithium-ion Smart Battery 12V-80AH.

A Nissan Leaf lithium ion battery set-up

corrosion and maintenance.

The basic battery cell comes in various shapes and sizes from the small AAA battery to large prismatic cells each weighing several kilos. Smaller cells mean a high cell count, which means more connections and potential points of failure. However, larger cells are harder to cool and can release more thermal energy if they fail.

Another key decision is which lithium-ion chemistry to use - the differences lie in the energy density and thermal stability of lithium. At one extreme is lithium cobalt oxide - commonly used in consumer electronics - which is both very energy dense and the most thermally volatile. At the other end of the spectrum is lithium iron phosphate and lithium-titanate which are often used in very large electric vehicles like buses and ferries. These chemistries have thermal stability but are less energy dense, so they require larger cells to deliver the same energy. A common middle of the road chemistry is lithium NMC (oxides of nickel, manganese, and cobalt) a compromise between reasonable thermal stability and energy density. These cells are increasingly being used in electric vehicles.

Cells are connected in series and parallel to form modules, built into a pack and enclosed in a case that is sealed against dust and water, preventing mechanical abuse and physical access.

Whereas lead acid batteries are straightforward to manufacture, lithium-ion battery production is similar to semiconductor production, requiring clean rooms with tight control of air contaminants and humidity, material purity, tolerances and cleanliness. World class manufacturing quality control and automation is therefore required which increases capital costs.

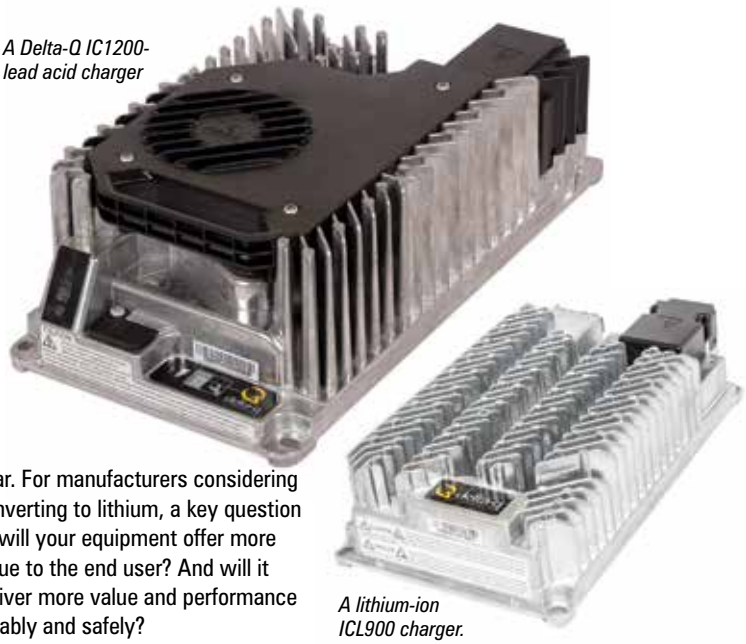
Benefits of lithium-ion

The most noticeable benefit of lithium-ion batteries is that they are up to four times lighter and three times smaller than equivalent lead acid batteries. This means you can fit the same energy in less space, enabling a smaller, lighter product, or you can pack more energy into the same space, providing a longer run time and range. Lithium also delivers higher power, enabling higher performance vehicles and machines to charge much faster and more efficiently. However to charge quickly a large amount of power is needed. Lithium batteries have much longer life than lead acid, delivering thousands of cycles instead of hundreds. In many applications, this means the batteries last as long as the machine they are installed in, allowing longer warranties and eliminating regular battery replacement costs.

"So why isn't everyone using lithium-ion batteries?"

The initial costs can be three to five times more than traditional batteries. As uptake and technology progresses that cost is falling each year. For manufacturers considering converting to lithium, a key question is 'will your equipment offer more value to the end user? And will it deliver more value and performance reliably and safely?

Manufacturing lithium-ion batteries



A Delta-Q IC1200-lead acid charger

A lithium-ion ICL900 charger.

Battery Management System

A Battery Management System is required to ensure that lithium cells are optimised for performance, life, and safety. The BMS monitors cell voltages, temperatures and currents, and from this data will estimate the battery pack state of charge, health, and power limits. If the individual cell voltage state of charge deviates drastically, the BMS will use cell level hardware to bring them back into balance. It then communicates the battery's status to other system modules, like a motor controller, charger, user display or service tool. Finally, it takes the necessary action to protect the cells by electrically disconnecting them from the system. It is critical for the BMS developer to work closely with the cell manufacturer, to ensure that the cells are operated and protected.

Charger integration

Although often considered an afterthought, the charging system is critical and has a big influence on battery life, safety and performance. A key decision is how fast and how often to charge. As discussed, faster charging generates more heat and hotter batteries age faster. Charge rates will also reduce when the battery is too hot or too cold to prevent premature degradation and aging. Lithium-ion batteries are no exception and will age faster at higher voltages and higher states of charge. For this reason, battery packs are usually not fully charged, but instead are limited to a reduced state of charge target.

"The trade-off between run time and battery life must be carefully considered and will look very different depending on the machine i.e. for a cell phone with a two to three year life, versus a spider lift designed for more than 10 years of life," said Chris Botting, manager of research at battery charging supplier Delta-Q Technologies. "The charger must be well integrated with the battery system and often includes communication such as CAN bus, Modbus, analogue or digital control signals."

"During integration, the charger's output quality should not be overlooked, as all chargers are not created equal. Excessive ripple current, for example, can cause cell heating and BMS noise. This can harm the battery, BMS and other system components, as well as interfere with the operation. Voltage control accuracy is also important to maximise the life and safety of lithium-ion batteries."

The needs of heavy duty scissor lift

While the lithium ion battery has many advantages for a wide variety of applications, the majority of access platforms - and large heavy-duty scissors in particular - will continue to use the lead acid, AGM or Gel batteries.

Crown deep cycle batteries.

A common battery and charger set-up

The high capacity, emission free heavy duty scissor is ideal for applications such as pipe fitting, racking and sprinkler installation with a need to lift men and materials to 20 or more metres in an enclosed environment. Contractors and rental companies that have invested in hybrid machines are however finding that all too often the engine is used more often than anticipated when working indoors and is therefore not the ideal solution.

However charging larger battery powered scissor lifts is also causing problems. Manufacturers including Holland Lift, PB Lifttechnik and Airo all offer three phase 380 to 415 volt chargers. However in the UK job sites are usually restricted to 110 volt power. Most machines come with dual or multi voltage chargers which have varying results. For example, a 24 volt 80amp charger is only capable of giving out 80 amps on a 230 volt AC 11 amp supply, dropping by half to 40 amps when using 110 volt AC 11 amp supply. A 48 volt 50 amp charger can only give out 50 amps on 230 volt AC 14 amp supply dropping to 25 amps when using a 110 volt AC 14 amp supply. The limited power dramatically shortens battery life because the charge cycle is never really completed correctly.

A solution from Aberdeen-based Norco group - which has more than 30 years experience in the offshore oil exploration and production industries - is the Traction Charger that runs on 110 volt AC 32amp supply, giving a full 48 volt DC 50A output.

So what are the implications of undercharging a battery?

It is acknowledged that undercharging over a period of time is one of the most destructive forms of abuse for a battery. The formation of excessive amounts of lead sulphate - sulfation - causes the positive plates to expand and break up while the negative active material hardens and loses capacity. The best protection against under charging is a regular check of the specific gravity of the battery after the normal recharge has been completed. This is challenging on site, especially if you are dealing with VRLA, Low Maintenance Batteries such as AGM or GEL which are now fitted as standard on some access equipment. If readings show consistent undercharging, remedial action must be urgently taken.

Sulfation is the build-up of lead sulphate causing plates to expand and break

The Skyjack SJ8841 RT set-up with two chargers one above the other

The new SJ8841 set-up from Norco using one Genie high output AGM charger

A Fronius Selectiva Plus charger

Heat is the biggest killer

For most rental companies short on time and space, scissor battery packs are charged with the battery trays closed. This is bad for the batteries as the heat generated in the process is unable to escape as easily and therefore heats the battery unnecessarily, adding to the sulfation and decreasing the battery life.

With very long lead times for new large heavy duty scissors - 12 months or more - several rental companies are having to extend the lives of its existing machines. One machine which can suffer from battery problems if not charged correctly is the Skyjack SJ8841 RT which has a very full battery tray and therefore very little ventilation space, unless left open during charging. It also has two chargers stacked above each other with a risk of the top unit being 'cooked' by the heat produced from the lower unit. Increased heat means a lower output therefore a greater likelihood that the batteries will not be sufficiently charged.

Norco offers a solution to this, replacing the lead acid batteries with smaller but heavier AGM batteries - which it claims produce 10 percent more power - while providing more space between the pack, reducing temperatures. The two large charger boxes are replaced with a much smaller, high output AGM charger resulting in a more efficient and cooler set up. It claims that with closed charging the eight unit battery pack will hardly last a year, while its AGM set up should last a good five years, while virtually eliminating maintenance issues.

Skyjack SJ8841 RT

The new set-up with smaller AGM batteries with a spacer box inbetween

The old battery set-up in the SJ 8841 RT