Lithium-ion Batteries Target Temperature Extremes

Jeffrey VanZwol, Micro Power Electronics

OEMs are requesting rechargeable Lithium-ion battery packs for portable devices that operate in explosive, as well as extreme hot and cold environments. Many portable military devices are used in very cold (-40º Celsius) environments, and many medical devices need battery packs that operate after exposure to 137º C steam sterilization, both exceeding the limits of conventional lithium-ion technology. This article discusses new lithium battery technology and packaging techniques that enable portable devices to operate in wider temperature extremes.

Many portable radios must perform at -40º C. Conventional Lithium-ion chemistry starts to suffer as the temperature drops below freezing. As the temperature drops below 0° C, the internal impedance of the battery increases. The result of this effect is “voltage droop”, which becomes more pronounced at -20º C or lower. Cell capacity is also reduced during these lower temperatures. If these cells are used or stored at -50º C, irreparable damage may occur under certain conditions to internal separators within the cells, making the cells a safety hazard.

As an example, Figure 1 presented the discharge curves for both mixed-metal-oxide and Cobalt Oxide Li-ion cells. The mixed metal oxide cells, represented by the blue curves, provide more competent performance -30º C. The voltage droop is more pronounced with the Cobalt Oxide cells, presented by the pink and yellow curves.

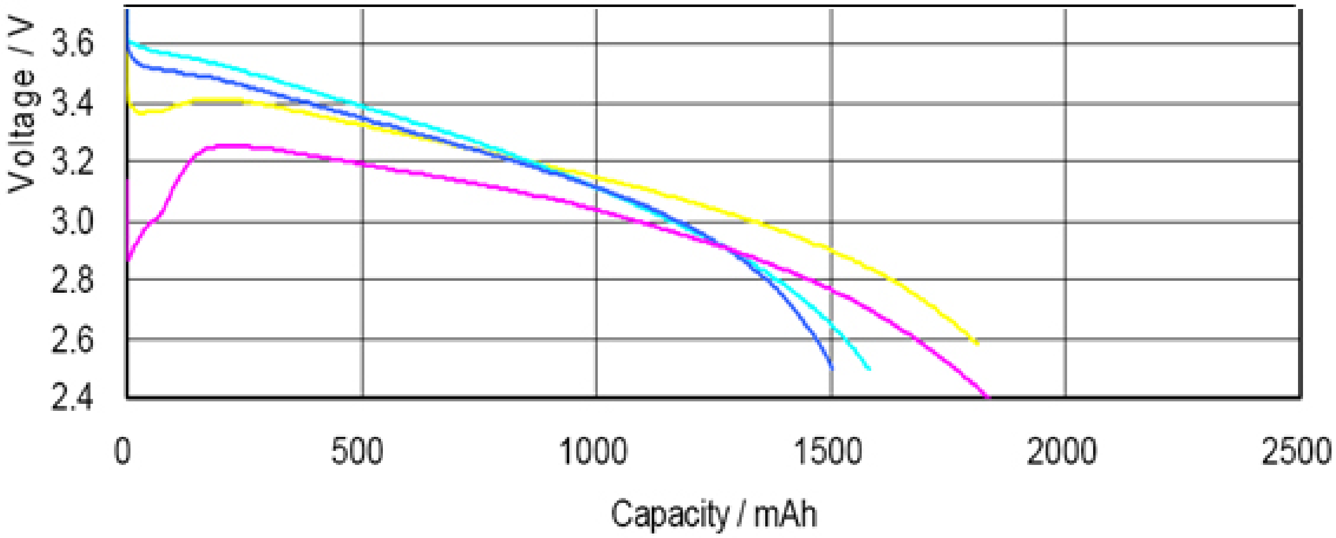

Figure 1. Mixed-metal-oxide cells provide better low temperature performance than Cobalt Oxide cells.

Luckily, cell vendors have refined the material formulation to improve the lower temperature performance. They balance the blend of their mixed metal oxide formulations (predominantly Nickel, Aluminum, Manganese, and Cobalt) to deliver power below the conventional -20º C limit while maintaining competitive price points. Boston Power offers Li-ion cells which support moderate current delivery at -40º C. Additionally, Saft offers a more specialized line of Li-ion cells that are optimized for low temperature performance.

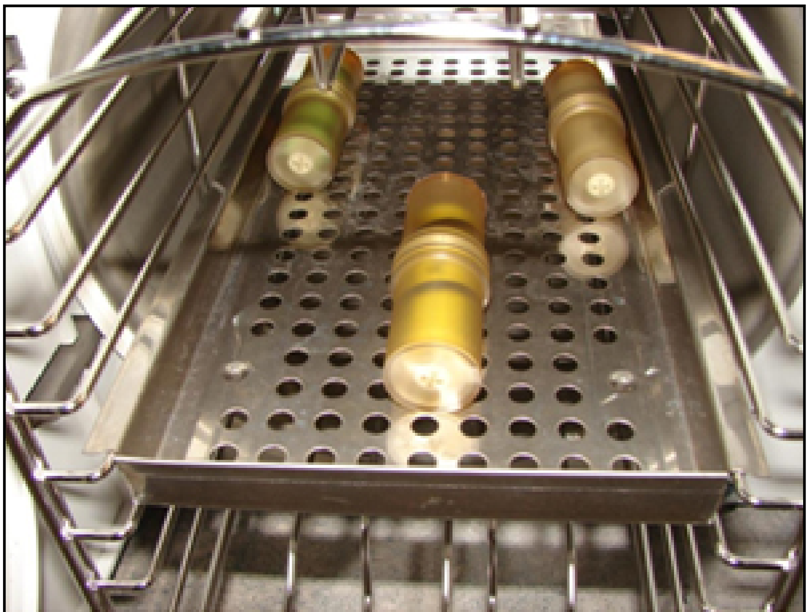

Figure 2. New cells are initially sterilized in an autoclave to ensure the cells fail-safe, rather than entering a state of thermal runaway.

If the combination of higher current and lower temperatures eliminates Li-ion as a viable chemistry, one can consider utilizing Lithium primary cells as they operate down to -40º C. Primary

Lithium cells can deliver more current at lower temperature. Cells based on Li/MnO2 chemistry use a solid cathode, while the Li/SO2 cells uses a liquid cathode. Liquid cathode systems suffer from a “voltage delay” phenomenon, which causes the resulting voltage to be momentarily suppressed when a load is applied, particularly after extended periods of storage. Saft and Ultralife are major suppliers of primary Lithium cells.

Switching to the other end of the temperature spectrum, many surgical instrument manufacturers wish to sterilize their tools and battery packs using steam sterilization. Using an autoclave, the sterilization process uses pressurized steam heated to 137º C. The exposure to this temperature can range from three to 30 minutes. Traditional chemistries for these battery packs were Nickel-based, NiCad or NiMH. However, the upper limit for battery storage without permanently damaging a Lithium cell can range from 120 to 170º C. Some cells will experience thermal runaway with prolonged exposure to 137 º C, others will not. However, by balancing the blend of their mixed-metal-oxide and Iron Phosphate formulations, cell vendors have raised the limit of high temperature tolerance so a brief exposure to 100+ º C temperatures does not reduce cycle life. These new cell varieties, combined with innovative packaging and insulation techniques by the pack manufacturers, are bringing Lithium-ion batteries to the forefront of this market.

Figure 3. Batteries sterilized in an autoclave require tight seals around contacts to resist both temperature and water vapor in a pressurized environment.

To ensure a watertight seal between the two halves of the plastic pack enclosure during sterilization, ultrasonic welding is recommended to join plastic case surfaces. Unlike alternative methods of sealing enclosures, such snap-tight seals or adhesives, watertight seals are possible with ultrasonic welding. Ultrasonic welding ensures the enclosure is resistant to shock or impact, as the resultant joint strength can match the strength of the welded material.

During sterilization, a common area for humidity penetrating seals of the battery enclosure is around the contacts. Even if the contacts are insert-molded in the battery enclosure, vapor from a pressurized autoclave chamber can still enter the enclosure around the contacts. A common technique for sealing contacts is to place potting compound, such as polyurethane or silicone, on the interior of the enclosure behind the contacts. This will prevent any penetration of vapor through this barrier into the enclosure interior.

Jeffrey VanZwol
VP of Marketing
Micro Power Electronics
www.micro-power.com [1]

Links:
[1] http://www.micro-power.com