Ensuring Safety in Battery Pack Assembly

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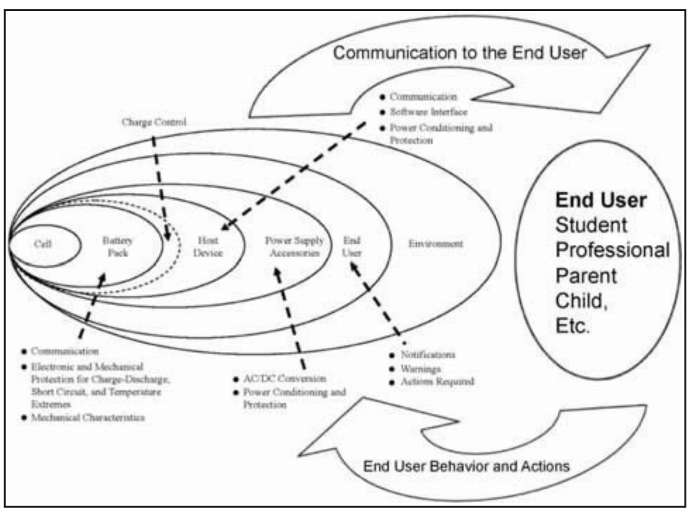
Battery problems can occur at every level of the battery manufacturing and use process. All facets of battery manufacturing and use must work together for a safe end product. Even extensive cell, pack and system testing will not completely prevent any and all battery issues from occurring, but it will greatly limit them.

The culprit of recent battery incidents and recalls is wide and varied. Accomplished manufacturers of cylindrical 18650-size cells have now produced well over 2 billion cells and are far along the learning curve for producing cells. However, even accomplished cell and pack manufacturers still experience in-house and field failures. To complicate matters, new players are sprouting up in the lithium ion cell market. Lithium-ion cells and packs are being produced by "beginners" with no experience and sometimes a disregard for safety measures due to price pressures.

The reason for recalls at the cell level include issues such as tiny particles getting caught in electrode material causing internal cell shorts, and electrode slitters not making clean cuts which cause burring on electrode edges resulting in internal short circuits. At the pack level, poor battery design has caused issues in that when a product is dropped at a certain angle, the safety devices are compromised. Solder balls have come loose on safety boards and caused internal shorts inside packs. At the system level, charge regimes such as pulse charging of batteries weaken separator material in cells and allow internal shorts. In addition, counterfeit cells and packs made to inferior standards (some packs not even containing required safety devices) have entered the market.

The battery industry is essentially self-policing. Starting at the cell level, reputable cell manufacturers dictate assembly procedures to their pack assemblers and approve applications. However, not all manufacturers share the same philosophy. Recent factory fires and cell shortages have exacerbated the black/gray market cell industry. Testing and adherence to established agency standards such as UL and CSA are recommended, but not absolutely required for most applications. Pass criteria for these abuse tolerance tests generally revolve around the lack of an explosive or flame event on a yes/no basis for a defined parameter. Given this, cells and packs can be designed for the sole purpose of passing a particular test. The only actual requirements for testing battery packs for safety fall under the UN Transportation guidelines, a system which is, in reality, also self-policing.

Ensuring a safe product begins at the cell level and ends with the user. It is about understanding the intended use of a product, and mitigating reasonable and foreseeable misuse that may occur. IEEE P1625, the Standard for Rechargeable Batteries for Portable Computing, was the first standard to encompass all levels of the battery manufacturing process and include the customer experience. IEEE P1725, the Standard for Rechargeable Batteries for Cellular Telephones, followed. This graph from the recently updated P1625-2008 standard IEEE illustrates the thought process:

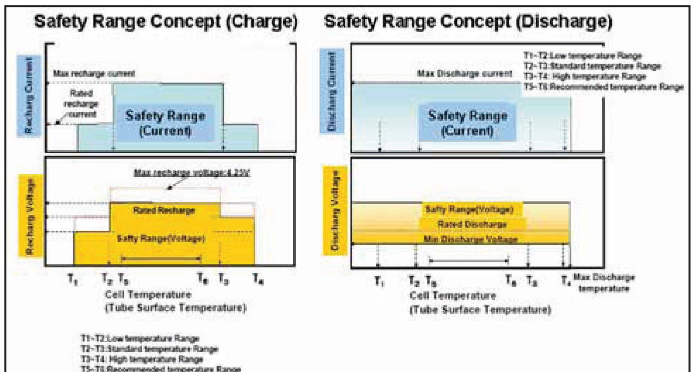


In addition, the Japan Electronics and Information Technologies Industry Association (JEITA) and the Battery Association of Japan (BAJ) have also formulated a standard for lithium ion batteries for notebook computers. Their standard also encompasses a holistic approach to designing a successful battery.

Ensuring safety at the cell level includes the addition of internal vent mechanisms, the use of internal positive temperature coefficients (PTCs), good separator design and a consistent manufacturing process. Testing to and for agency approvals help to mitigate failures as these include testing for overcharge, forced discharge, crush, thermal abuse, external and internal short circuit. Testing not only new cells, but cells that have aged or experienced a number of cycles, helps to eliminate possible field issues.

At the pack level, the addition of safety components goes a long way in lessening risk. A safety circuit, protecting packs against overcharge, overdischarge and overcurrent, is mandatory. A secondary protector, such as a current and/or temperature-based component (PTC or a thermostat) is absolutely recommended. A thermistor to monitor battery temperature while charging is also desired, especially for NiMH chemistries. For larger packs, a one-shot chemical fuse is suggested. Good manufacturing practices and good design, such as use of trained operators, the addition of extra insulation and recessing contacts also add to a pack's safety rating. Verification that safety devices are actually working packs is also needed: overcharge/overdischarge, short circuit, continuous charge tests are among industry standard.

At system level, the charger is the first line of defense. A charger matched to the specifications of the battery is non-negotiable. Different cell chemistries all have their own recommended charge methodologies. In lithium ion cells, the overcharge condition is the condition in which cells are most volatile. Charge method, voltage, charge rate and temperature all must be considered. Test verification of charger with the battery must be performed. Ensuring that the end unit does not cause any unforeseen current spikes or shorts (mechanical or electrical) is compulsory. In addition, the battery must be appropriate for the environment in which it is used. A battery specified to operate in 0°C to 45°C has no business being used where temperatures will be above or below these levels. The following graph from JEITA/BAJ illustrates the safety range for voltage for both charge and discharge.



Source: "Safe Use Manual for Lithium Ion Rechargeable Batteries in Notebook Computers." Japan Electronics and Information Technologies Industry Association and Battery Association of Japan.

All the cell, pack and system testing is for naught, though, if the user does not understand or respect the battery for the high energy system that it is. Shipping issues and improper packaging have caused the greatest number of single battery incidents. Shorting can occur in single shipments, bulk shipments and where batteries are contained in or packed with equipment. Shipping issues are not limited to battery packs; they can just as easily occur with coin cells or so-called consumer single cells. Without proper packaging, incidents will occur. The recent harmonization of the DOT with new requirements from IATA and ICAO mandate specific labeling and testing of packs and packaging for battery shipments. Shipping personnel must be trained, customers must be educated and regulations must be adhered to.

So how to ensure a safe battery pack? Ensure all levels of battery manufacturing are addressed: cell, pack, system, user and environment. There is no substitute for using experienced, high quality, reputable cell and pack vendors. Utilize accepted industry practices. Design in early. Don't use price as the lead item. Design and test per industry standards, and perhaps more importantly, test per your application requirements. A holistic approach in designing systems involving batteries is an absolutely necessary path for a satisfactory user experience.

Katherine Mack has more than 20 years of experience in designing and developing custom battery systems for industrial and medical OEMs requiring portable power. Katherine has focused her career particularly on portable cell chemistries, cell vendors and smart battery solutions. She was an original member of the IEEE P1625 Working Group for establishing Safety Standards for Mobile Computing.

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