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# Cell Constuction Analysis Ensures a Robust System and Identifies Potential of Internal Shorting

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In today's fast paced market for portable electronics, the lithium-ion battery has become a highly utilized energy solution. As consumer products continue to require more energy in smaller packages, understanding the construction and performance of the cell is critical to the overall battery quality. Cell construction analysis can provide an in-depth knowledge of individual cell construction and a prediction of potential performance issues in the early assessment stages, before the product reaches the market. Cell construction analysis can be a powerful tool in ensuring a robust system.

Lithium-ion rechargeable battery manufacturers are concerned with the safety and performance of their products, so they design batteries with circuits to protect the cells from external stresses or hazards. Regardless of the type of safety circuits utilized, a cell within the pack that has an internal defect cannot be protected by the battery level safety circuit. Internal shorting is a major cell defect that can result in performance issues, ranging from high self-discharge to the extreme of venting or explosion. Many times internal shorts are caused by a latent defect in the cell design or construction. Detecting these defects through testing can be very difficult since, in many cases, the defect is only randomly exposed in a large sampling of a particular cell. An understanding of the robustness of a cell can provide an avenue for implementing tighter quality assurance controls to reduce the likelihood of issues in the field.

## The Best Way to Benchmark the Robustness of a Particular Cell

One option is to utilize testing from existing regulatory and industry safety and/or performance standards. This method can be time, cost and product sample intensive. Another way to assess the situation is to try to simulate an internal short in the cell by the application of external stress forces. Examples of this type of testing may include an impact, crush, rod crush and mechanical shock or nail penetration. Since these tests use an external stress, internal reactions can be difficult to reproduce. Additionally, an internal short in a cell will normally be a very isolated event such as a hole in the separator caused by a sharp edge or burr. Simulating this isolated event by application of an external stress on all layers of a cell's jellyroll could lead to a failure mode that will look nothing like a typical internal short found in a mass produced cell. There are also latent defects that would never be seen by performing these external stress tests. Consequently, you could perform all of these tests and still see performance issues in the end product. Additionally, the failure criteria for the industry standard abuse tests are typically venting with flame or exploding. These are extreme conditions and do not address the reduced level performance concerns.

While safety testing is imperative in the analysis and the understanding of a cell's performance in stress situations, it is not sufficient to fully understand the best way to understand the robustness of a cell design or construction. The best way to understand the robustness of a cell design is to actually look at the construction of the cell. Engineering drawings can be a useful resource, but they do not reveal how the cells are actually constructed in a true manufacturing setting. To see and understand the construction of a cell, it needs to be opened and physically analyzed.

## What is Cell Construction Analysis?

Cell construction analysis is a systematic approach to identify cell weaknesses, design flaws and any robust and redundant safety features. The analysis must be conducted with fully discharged cells. The cell is cut open and critical areas are identified. The analysis includes observations within the construction where the potential exists for an internal short circuit to occur.

A cell is an electro-chemical system consisting of positive and negative electrodes separated by microporous polypropylene and/or polyethylene layers called separators. The electrodes are involved in reduction and oxidation types of reactions. The electrolyte is the ionic conductor that ensures the transfer of ions between the positive and negative electrodes. The electrodes and separator may be wound together forming a jellyroll or stacked in rectangular parallel formation. The most common configuration is the jellyroll construction. The jellyroll system and connections are enclosed together in an aluminum or steel can or pouch.

An internal short circuit condition occurs when a circuit path is created between the positive and negative poles of the cell. This low resistance connection across opposite polarities creates excessive current flow and heat generation. Because the opposite charged electrodes, internal connections and cans or pouches are positioned very close together, the probability of internal short occurring significantly increases. Therefore, it becomes imperative to assure cells are robustly designed and consistently manufactured.

## Linking Quality Tools and Cell Construction Analysis

To understand all the implications of any particular cell construction feature or deficiency noted during the construction analysis, an assessment of the individual cell manufacturer process capability is essential. By understanding the most likely areas for defects to occur and the processes by which these items or areas are manufactured, a true picture of the robustness of the cells can be understood. The preferred method for doing this is to utilize design and process FMEA tools, along with the construction analysis notes.

A common example of an area of concern in an aluminum can cell construction is the shape, length and enclosure of the negative current collector. Aluminum can cells have the cell can as the positive terminal, and the button as the negative, whereas steel can cells have the can as the negative terminal and the button as the positive. If the negative current collector (also called negative tab) is not properly insulated and/or segregated above the jellyroll, the negative tab can touch the positive cell can and produce a short.

Many cell manufacturers design redundant systems to avoid the most common situation for internal shorts. The use of construction analysis can easily identify the presence of these more robust design features. Construction analysis can also identify potential cell performance issues such as high resistance that can cause shorter cycle life, low capacity, leakage and low voltage.

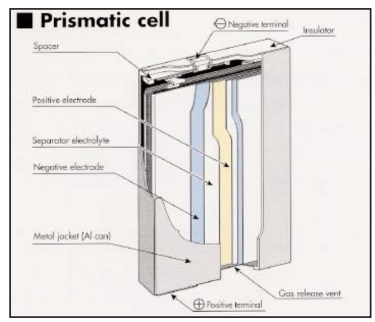


**Diagram of Li-ion Cell Internal Construction**

## Expanding Cell Construction to All Cell Types

Even though only lithium-ion prismatic cells have been specifically addressed here, the principles of the construction analysis procedure can be applied to any type of cell. It would need to include a basic understanding of the issues or concerns of the chemistry in question, as well as the size and formation type. Even without opening the cells, some external cell features, such as vent type and button constructions, can also be observed for potential concerns. Also, the use of non-destructive x-ray images can reveal internal cell images, such as current collectors shape and spacing, without ever opening the cells.

Cell construction analysis is a powerful tool for understanding mechanical robustness. This process allows us to determine the maturity of a cell manufacturer's capabilities and their system design approach. Cell construction analysis requires the use of fewer samples. Plus, the process helps reduce time and resources. Cell construction is an ideal tool for quality assurance.

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