Effects of vibrations and shocks on lithium-ion cells

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Highlights:

- We investigated how vibrations and shocks affect lithium-ion cells.
- Cells were stressed with UN 38.3 profiles as well as real-world vibrational loads.
- Cells with a tight packaging and fixed internal components showed no damages.
- Post mortem analyses and μCT revealed a loose mandrel for the tested 18650 cells.
- Depending on the direction of motion, the loose mandrel caused serious damage.

Abstract

Lithium-ion batteries are increasingly used in mobile applications where mechanical vibrations and shocks are a constant companion. This work shows how these mechanical loads affect lithium-ion cells. Therefore pouch and cylindrical cells are stressed with vibrational and shock profiles according to the UN 38.3 standard. Additionally, a vibration test is set up to reflect stress in real-world applications and is carried out for 186 days. The effects of the load profiles on the tested cells are investigated by capacity measurement, impedance spectroscopy, micro-X-ray computed tomography and post mortem analyses.

The mechanical stress has no effect on the investigated pouch cells. Although all tested cylindrical cells would pass the standard tests, in certain cells stressed in a vertical position the mandrel dispatched itself and struck against internal components. This caused bruised active materials, short circuits, a damaged current collector and current interrupt device.

The investigations are not directly transferrable to all pouch or cylindrical cells but show that the mechanical cell design, especially the fixation of the internal components, determines whether a cell withstands vibrations and shocks. Depending on the cell design and the loading direction, long-term vibrational loads can have additional detrimental effects on lithium-ion cells compared to standard tests.

Keywords: Vibration; Mechanical shock; Durability; Mechanical failure; Safety; Lithium-ion battery

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