

UN Transportation Tests and UL Lithium Battery Program

Underwriters Laboratories Inc. - General Experience and Status Update

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Brief Status Update of UL Lithium Battery Program

1. Certification Enhancements

- 1. Completion of Construction Form Report
- 2. Development of new Standardized Appendix Pages
- 3. Continuation of Work on Production Requirements
- 4. Publishing of UL Subject 1642A, Outline of Investigation for Battery Separators (proposed inclusion in UL 1642)
- 5. Ongoing Research Dept. Internal Short Circuit Testing
 - Blunt Nail Crush Test,
 - Review of Forced Internal Short Circuit Test
 - Review of NASA Test Methods

The objective of the UL research project:

- develop a reliable and repeatable way to simulate an internal short-circuit.
 - the lithium ion cell shall remain SAFE even if an unexpected internal short-circuit occurs.

Methods analyzed to date as part of project:



the standard in safety

Types of Internal Short Circuits

•There are 4 kinds of Internal Short Circuit Conditions:



Blunt Nail Crush Test Method Overview

- Crush the cell with a Blunt Nail until detection of 100 mV open circuit voltage(OCV) drop
- Record OCV, temperature profile and qualitative test results.









Short Mechanism of BNC test



The CT-Scan of the tested cell shows the short was induced at

outer layer/layers.

the standard in safety

Critical Test Parameters for Blunt Nail Crush

- To control the scale of internal short (single layer short) accurately, some test parameters are critical.
 - Control of Press Speed Press Equipment with servo-motor using constant press speed at 0.1mm/s

R: 45°

- OCV Sampling Rate recommended OCV scan rate is 100Hz or more.
- Testing Temperature is one of the most critical test parameters
 - Controlling the temperature of the samples is important.
- Geometry/Sharpness of Blunt Nail
 - To avoid penetration of the cell's case while testing, the tip of the nails have to be rounded.
 - The nail with tip radius 0.9 mm and tip angle 45° (recommended for testing cylindrical cells)





Strengths of BNC test method

- Method does not require a lot of special sample preparation
 - Little change or deformation of sample during test
- A short circuit is obtained each time
 - 100 mVdc OCV drop requirement of test
 - Repeatable results

Weakness of BNC test method

- Cannot control exact location of short because blunt nail is pressing on the outside of the can
 - Short Mechanism depends on Internal Construction
 - Different designs may lead to different types of internal short circuits (i.e. CU – Al + Cu – Anode or CU – Al only)
- Some difficulty with controlling the number of layers shorted
 - Improved results with improved test set up

UL Lithium ion Battery Research Project - FISC Test Analysis

- •Strengths of FISC test
- Can control location of internal short circuit
 - Place particle in preferred location
 - Anode to Cathode short represent field failures that may not be picked up with standard mfg. production testing.
- Can obtain single layer short



Weakness of FISC Test:

- Safety concerns
 - Special equipment and cell preparation facilities
- Difficult to disassemble and reassemble cells for the test
- Can induce single-layer short, but it may NOT always be an Anode-to-Cathode short.



•If the separator is strong it is possible that the L-shape nickel particle will penetrate the cathode first and then pierce the separator to induce the short. Under this condition, the short is Cathode/Al-to-Anode but not a typical short of Anode-to-Cathode.

UL Lithium ion Battery Research Project – NASA Test Analysis

NASA Lithium ion battery test:

- Some similarities to UL BNC test
 - Use blunt nail/rod to press from the outside
- Differences to UL BNC test
 - Results influence vibration testing on samples
 - Parameters are different
 - Pass/Fail criteria of test differs
 - Pass/Failure dependent upon results of vibration testing
 - If cells fail rod test, subject to more severe vibration
 - If cells pass rod test, subject to less severe vibration



NASA method

UL Battery Standards, Update

•UL 1642 and UL 2054

- Harmonization with IEC standards
- IEEE 1625 GAP Analyses TG
- · Currently proposals under 2nd review vote
- STP meeting in 2009

•UL 2575

- Battery systems for tools and appliances
- First Draft completed initial review period
- STP meeting on November 16 and 17, 2008
- Plan to Harmonize IEC 60745 and IEC 60335 to UL 2575 with addition of Appendix "P" to standards

•UL 810A

- Electrochemical Capacitors
- ANSI standard for Ultracapacitor cells and modules
- Stationary and portable applications non-vehicular use

UL History with UN Transportation Tests

UN tests at UL

- Service offering Under UL CITS
 Program
 - Primary and secondary Lithium Battery
 - Cells and Packs
 - Testing primarily conducted at UL NBK office

•Similarities between UN Transportation Tests and UL Safety Tests

- Altitude Simulation
- Thermal/ Temperature Cycling
- Vibration
- Shock
- External Short Circuit/Short Circuit (55°C)
- Impact
- Overcharge/Abnormal Charging & Abusive Overcharge
- Forced Discharge

T1 Altitude Simulation

- Similar to UL altitude simulation test
- · No known failures to this test

T2 Thermal

- Similarities to the UL temperature cycling test
- No known failures to this test

T3 Vibration

- Similar to UL vibration test but conducted on both cells and packs
- No known failures for cells, but may be more difficult test for packs

T4 Shock

- Similar to UL vibration test but conducted on both cells and packs
- No known failures for cells, but may be more difficult test for packs

T5 External Short Circuit

- Similar to UL 55C short circuit test
- Need to designate range for resistance, as this has affect on test results (recommend using 80 +/- 20 mOhm)
- If protectors relied upon to pass test, need to indicate they are required for cell/battery
- Is the 170C limit appropriate for all lithium chemistries?
- External polymeric materials used for most packs are not rated for 170C temperatures

T6 Impact

- Similar to UL impact test except not tested under fully charged state
- Need to address polymer cells (test on thin side as noted for prismatic?)
- •Need to better document details/dimensions of metal bar
- •Metal bar stay in place for 6 h? (may be heat sink)
- Test not always easy to conduct with odd shaped, large and small cells
- Why not test fully charged cells?
- Crush test (flat plate type test)?



T7 Overcharge

- Similar to UL abusive overcharge test
- Need to address protectors required to pass this test
- Problems with small packs which rely upon ptc's for protection
 - Leakage current may pass through PTC upon its operation
 - If enough leakage current passes through, becomes CV test limited only by supply voltage

T8 Forced Discharge

- Not similar to UL forced discharge test, but same goal
- More severe as it does not allow reliance on pack protection against cell reversal



General Observations

- Disassembly vs Rupture
 - Is there a need for both disassembly and rupture terms
 - Use of cage to determine disassembly necessary?
 - May not be practical in some cases
- Samples
 - Use of less samples for conditioning and tests

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Questions?

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