

Illustration on test items of Nail penetration, Crush and Oven

EVS-GTR IWG 6th meeting
18th-20th Nov. 2014, Korea

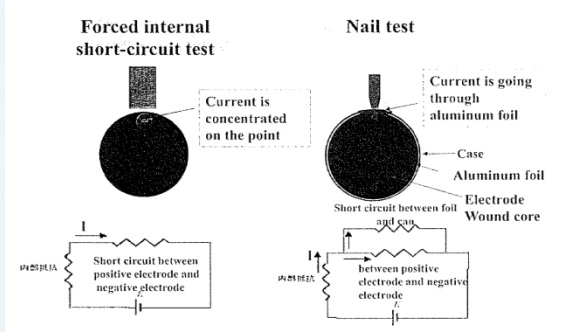
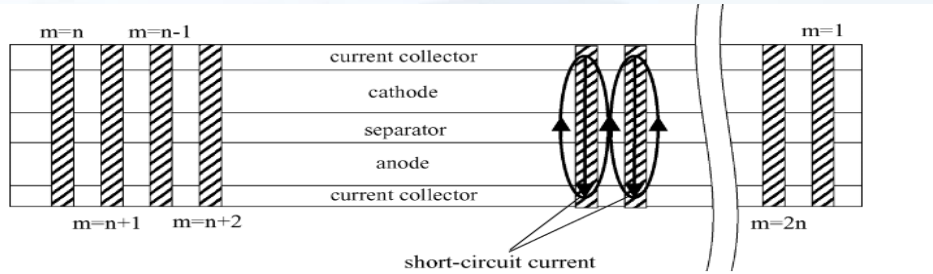
Nail penetration test

Evaluation of internal short circuit

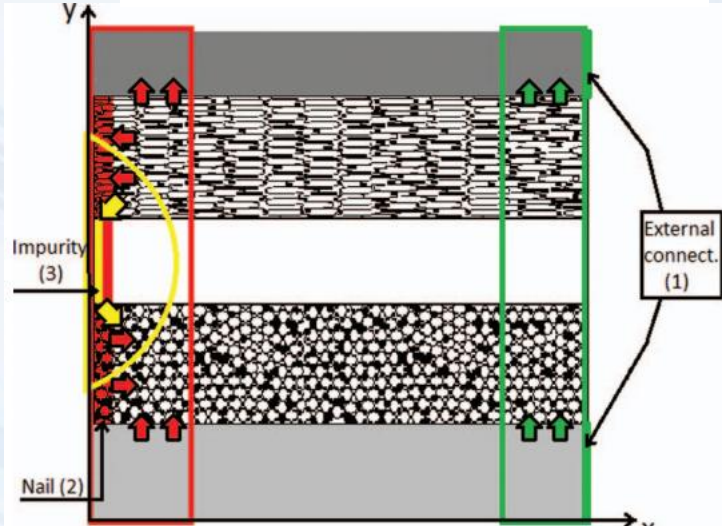
Mechanism of nail penetration test

➤ Both the internal short circuit (ISC) and the external short circuit (ESC) can happen simultaneously through the passage by the penetrated nail.

When the laminated lithium cell is penetrated through, ISC may occur at $2n$ regions of the electrode sheet wound n times in the cell [1].



The electrical energy would be released through the ISC and the ESC during penetration test. Both the ISC and ESC would happen together [2].



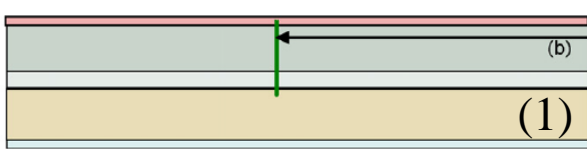
[1] Y. Yamauchi, K. Mizushima, Y. Satoh, S. Yamada. Development of a simulator for both property and safety of a lithium secondary battery. J. Power Sources. 2004 (136): 99-107.

[2] T. G. Zavalis, M. Behm and G. Lindbergh. Investigation of short-circuit scenarios in a lithium-ion battery cell. J. Electrochemical Society. 2012, 159 (6): 848-859.

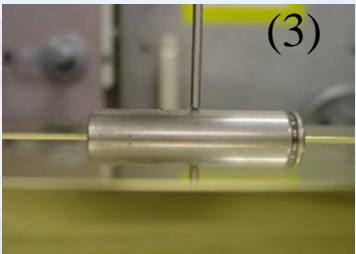
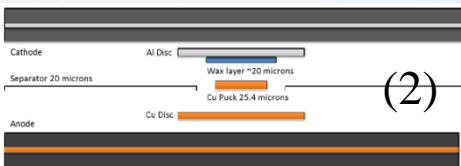
Replacement of nail penetration

- Nail penetration test item is introduced to simulate the ISC behavior.
- Hope to formulate a more reasonable way to simulate ISC to upgrade nail penetration.
- The researchers have proposed some ways to simulate the ISC, not by nail penetration, as follows.

- (1) Battery Association of Japan (BAJ)/ Celgard: disassemble cell and place a nickel metal particle at certain location, then press to trigger the ISC.
- (2) National Renewable Energy Lab: on-demand activation short circuit by PCM material.
- (3) Sandia National laboratory: blunt rod pinch.



Short Circuit between the copper current collector and the cathode active material using a nickel particle



[1] J. Lamb, C.J. Orendorff. Evaluation of mechanical abuse techniques in lithium ion batteries. J. Power Sources, 2014, 247: 189-196.

Replacement of nail penetration

- Discussions are needed to find a way which can simulate the ISC better.
- Nail penetration test is more severer with the happening of the combination of the ISC and ESC than that of the ISC or ESC respectively.
- General speaking, passing nail penetration test is a necessity for passing the ISC test to ensure the safety performance.
- It's necessary to keep nail penetration test item before we find a better way to simulate the ISC.

Crush test

Crush test

- Crush test item can be used to simulate potential hazard caused by collision, such as cell deformation.
- Crush test item can be used to evaluate the anti-collision capability, to simulate the ISC and to evaluate the hazard caused by electrolyte leakage.
- Scientific research on the crush simulation just started in MIT and Tsinghua university, etc.



[1] E. Sahraei, J. Campbell, T. Wierzbicki. Modeling and short circuit detection of 18650 Li-ion cells under mechanical abuse conditions. *J. Power Sources*, 2012, 220: 360-372.

[2] CERC-CVC technical report, 2013.

Crush test

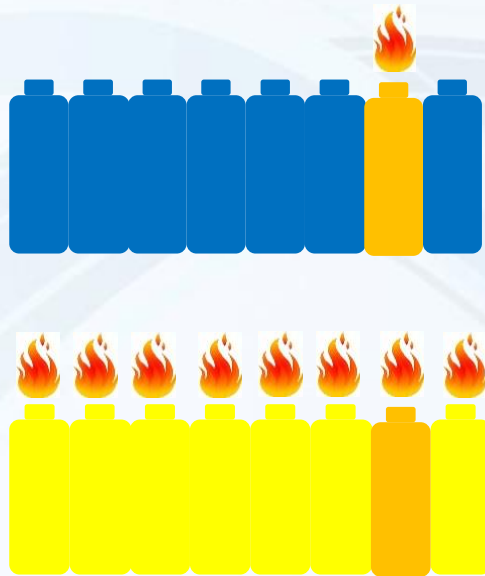
- Without the constraint of crush test item, it might be possible that some battery manufacturers reduce their requirements on the structure design to cater the needs of higher energy density battery system.

Oven test

Evaluation of thermal propagation test

Thermal propagation issues

- The cell with the happening of thermal runaway phenomena is not completely avoided during practical application.
- The thermal propagation of the single cell to the surrounding cells may cause serious consequences, such as fire or explosion, etc.
- The thermal propagation of the single cell to the surrounding cells should be prevented, especially in the condition of the thermal runaway.



Oven test

- Oven test item is used to evaluate the possibility of the thermal runaway for one cell that suffers unexpected heating.
- Oven test is a better way to evaluate the thermal performance in cell level.
- Oven test would provide the uniform and reproducible test data.
- Suggest oven test item on the cell level be kept, because the thermal runaway will propagate to the surrounding cells in a very short time, the cell should be tolerant to a certain high temperature without the thermal runaway happening.
- The thermal propagation test of module or system is also necessary for the evaluation of module or system capability of preventing the thermal propagation.
(module is designed with standardized configuration)

Oven test criteria

- Heat the cell up to 130°C, and keep this temperature for at least 30 min with the requirement of no fire and no explosion.
- Heat the cell up to 130°C in the adiabatic environment with the requirement of no thermal runaway, no fire and no explosion.

谢谢！
Thank you!