



HOW SAFETY STANDARDS ADDRESS THE HAZARD OF FIRE PROPAGATION IN BATTERY SYSTEMS

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Agenda

1. Intro - Incidents involving lithium ion over the course of its commercial use
2. Reasons for those incidents
3. What is propagation and how can it be prevented?
4. Background on test methods to determine resistance to propagation
5. UL 1973 Propagation Task Group
6. Conclusion

Intro - Incidents involving lithium ion over the course of its commercial use

Since the widespread commercialization of lithium ion batteries, there have been well publicized incidents that have occurred.



2005-2006
Notebook
Computer
Fires

2011
Chevy
Volt
test
vehicle
fire

2012
Boeing
787
Dream-
liner
battery
fires

2013,
Port Los
Angeles,
WA
stationary
battery
fire

2013-
2015 E-
cigarette
Fires

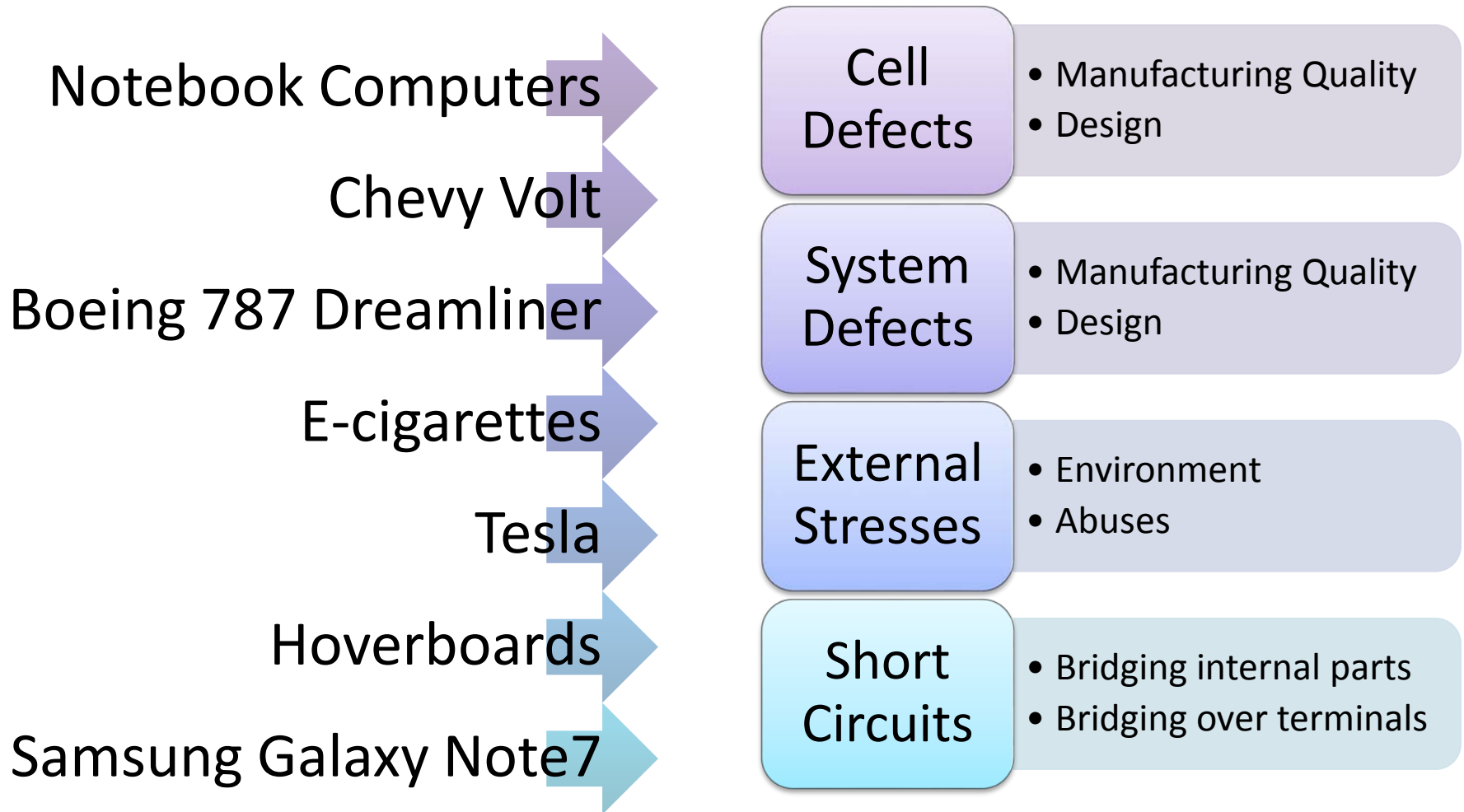
2013,
2014
Tesla
vehicle
accident
fires

2015-
2016
Hover-
board
Fires

2016
Sam-
sung
Galaxy
Note 7
Cell
Phone
Fires



Reasons for the incidents



Lithium ion has proven to be safe but stuff happens!

Reasons for the incidents

**All of
these
incidents**

.....

- Notebook Computers
- E-cigarettes
- Hoverboards
- Samsung Galaxy Note7
- Chevy Volt
- Tesla
- Boeing 787 Dreamliner

Led to propagation of fire



What is propagation and how can it be prevented?

“Cascading” can lead to propagation of fire external to the device under test.

According to UL 1973:



CASCADING – The runaway failure or thermal propagation of a battery system or battery module when:

- One battery cell is triggered into catastrophic failure and this cell causes the failure of neighboring cells; and/or
- Continued thermal propagation of catastrophic cell failures until part of or the entire system is on fire or causing excessive hazardous gas generation or leakage of hazardous liquids.

What is propagation and how can it be prevented?

Battery modules/systems need to be designed to prevent a single cell failure from cascading/propagating to the outside of the enclosure through:

1. **Use of well designed, well manufactured cells** that are not susceptible to failure during anticipated worse case use scenarios
2. Design reliable control systems that **maintain all of the cells within their specified ratings**
3. Use fire resistant materials, and provide adequate spacings between cells and thermal controls to **prevent overheating and the spread of heat/fire should a cell fail**

What is propagation and how can it be prevented?

UL 1973 requires that non-metallic materials meet

- levels of flame resistance and
- have thermal properties sufficient for normal use exposures

UL 1973 requires that cells comply with cell safety requirements

- UL 1973 requires that controls maintain the cells within their specified operating regions

UL 1973 requires that safety critical electronics and software controls meet functional safety criteria

UL 1973 requires that batteries comply with tests representative under normal use and abuse conditions

UL 1973 includes a propagation test called the “internal fire test”

UL 9540 requires batteries to comply with UL 1973

Background on test methods to determine resistance to propagation

The UL Internal Fire Test

- UL 2580 and UL 1973
- Concept for UL test came from SAE J2464, RESS Abuse Manual's Passive Propagation Resistance Test

SAE J2464 Passive Propagation Resistance Test

- evaluates the ability of a DUT to withstand a single cell thermal runaway event so that a thermal runaway event does not propagate to adjacent cells.



Background on test methods to determine resistance to propagation

SAE J2464 Passive Propagation Resistance Test

- Any technology RESS
- 100% SOC, test at module or pack
- The DUT is heated until the cells are 55 °C or the maximum operating temperature
- One cell within the DUT is heated in-situ to 400 °C (or until TR) in less than 5 min
- After initiation of TR, the heater is turned off and DUT is observed for 1 h
- Other methods of failing the cell besides heating to 400°C can be used
- Observations are made but no pass/fail criteria

UL 1973 Internal Fire Test

- Secondary lithium and sodium sulfur
- 100% SOC, test at module or pack
- One cell (in center) is subjected to failure (heating, nail, etc.) with failure to occur in 20 min
- After initiation of TR, mechanism is turned off or removed
- 24 h observation period
- Can repeat if necessary on cell in different location
- Pass/fail: No fire propagate to the outside of the DUT enclosure or explosion

Background on test methods to determine resistance to propagation

IEC 62619 also has a type of propagation test

- Lithium ion only
- Option to do FISC test, which is done on a single cell
- Single cell failure using one of multiple mechanisms
- No fire outside of DUT or rupture of enclosure of DUT

UL 1973 internal fire is essentially the same test but:

- Does not have option to do FISC test instead of internal fire test
- Required for secondary lithium and sodium sulfur

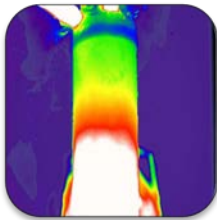


UL 1973 Propagation Task Group



Issues with Internal Fire Test

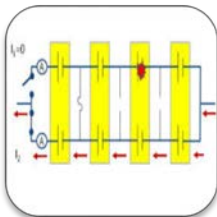
Lot of questions on the correct way to do the test????????



Is the chosen cell failure method adequate?



What are the steps to the cell failure?



What cell should be failed?

In the summer of 2016, a UL 1973 Internal Fire Task Group was set up

- Clarify intent of test
- Improve internal fire test method
 - Clarify intent
 - Ensure consistent approach
- Proposal was completed end of 2016
- Currently being processed out for preliminary review by the UL 1973 STP

UL 1973 Propagation Task Group

Put test in new section:
“Tolerance To Internal Cell
Failure Tests”



Include an appendix with
more details on cell failure
methods



Separate test into two parts:
1) lithium ion and 2) other
technologies



Change name of test to
“Single Cell Failure Design
Tolerance”

UL 1973 Propagation Task Group

Single Cell Failure Design Tolerance

A lithium ion battery system shall :

- be designed to mitigate a single cell failure leading to a thermal runaway of that cell

The cell failure mechanism used shall:

- reflect what is known or anticipated to occur in the field for a given technology or
- be a close simulation through the use of an external stress

The testing agency is responsible for selecting and demonstrating an appropriate method

an analysis to determine the cell location with greatest potential to lead to a significant external hazard shall be conducted

UL 1973 Propagation Task Group

Single Cell Failure Design Tolerance

Other technologies such as lithium metal, sodium sulfur, sodium nickel chloride, and lead acid are to be tested

- There may not be enough field data regarding their tolerance to single cell failure events,
- Basically the same test method as lithium ion testing

Cell failure technique, it should be representative of what can occur in the field

- The failure mechanism may be different than lithium ion and thermal runaway may or may not result
 - Consider failures due to potential cell manufacturing defects for that technology and/or
 - Cell and battery design deficiencies that could lead to latent failures of the cell

The DUT shall be in a condition that reflects its operating parameters

Conclusion

First quarter 2017
Preliminary review
(2 weeks review)

- Proposal may change based upon comments received

Will be part of the
2nd edition ballot
bulletin for the Bi-
national UL 1973
standard in 2nd
quarter 2017

Plans for
publication
before the end
of 2017

Thank you!

