



Outline for Lithium ion and Lithium Metal Cell/Battery Performance-Based Standard

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“Problem Statement” and “Goal” of ICAO Working Group

Problem Statement: A fire involving significant quantities of lithium batteries (UN 3090 and UN 3480) may exceed the fire suppression capability of the aircraft and could lead to a catastrophic failure of the airframe.

Goal: Develop performance-based standards based on the principle that hazardous effects will be contained within the package.



Thermal Runaway Definition

[A chain of exothermic internal chemical reactions within a cell resulting in a sudden increase in temperature and drop in voltage.]

Inducement of Thermal Runaway

One cell is heated until the cell enters thermal runaway. Various methods of inducing thermal runaway may be used (e.g., heating, overcharge). After thermal runaway in cell is initiated, the heater is turned off. The method used to create a thermal runaway is to be described and documented in the test report.

Package Testing

- The cell or battery pack is placed in packaging that will be presented for transportation
- For Li ion cells/batteries, the specified shipping SOC is set per manufacturer's specifications
- The testing is identical to that run at the cell or battery pack level
- Pass/Fail Criteria (see following page)



Package Pass/Fail Criteria

- **Pass**

- Package integrity maintained
- Package has not ruptured or released any debris or fragmentation outside of packaging
- No external flames observed
- Smoke venting is permitted
- Exterior sidewall temperatures of package cannot exceed 100° C in any location

- **Fail**

- Package has not maintained structural integrity
- Package has ruptured or released debris or fragmentation outside of packaging
- External flames observed
- Ignition of vented gases
- Exterior sidewall temperatures exceed 100° C



Battery Pack Testing

Li ion Battery Packs Shipped at > 30% SOC and Li Metal Battery Packs

- For Li ion battery, the battery is prepared at the specified shipping SOC per the manufacturer
- Cell temperature and cell voltage are monitored
- If heater is used to induce thermal runaway on the cell, a pre-test is run to determine what size heater is required to achieve a ramp rate of $5\pm 2^{\circ}\text{C}/\text{min}$. Alternatively, a closed-loop temperature controller may be used to achieve the ramp.
- If heater is used, cell heater is activated until either thermal runaway is achieved or the cell reaches 200°C , which is held for 20 minutes
- The battery pack is considered to pass if there is no disassembly or fire outside the battery pack

UL 1973

Safety for Batteries for Use in Light Electric Rail Applications and Stationary Applications

Internal Fire Exposure Test

- Energy storage system shall be designed to prevent a single cell failure within the system from cascading into a fire and disassembly of DUT
- Cell within energy storage system subjected thermal runaway or otherwise forcing the failure of a cell through any means necessary and determining whether or not failure remains safely controlled
- Once thermal runaway is initiated, heating mechanism is shut off
- 1 hour observation period

DUT = Device under test



UL 1973

Safety for Batteries for Use in Light Electric Rail Applications and Stationary Applications

Internal Fire Exposure Test

- Testing may be conducted on a representative subassembly consisting of one or more modules and surrounding representative environment, if it can be demonstrated that there is no propagation beyond the subassembly
- There shall be no fire propagating from the DUT or explosion of the DUT
- If thermal runaway condition cannot be initiated, as demonstrated through testing, the DUT complies with test

DUT = Device under test



Cell Testing

Li ion Cells Shipped at > 30% SOC and Li Metal Cells

- For Li ion cell, the cell is prepared at the specified shipping SOC per the manufacturer
- Cell temperature and cell voltage are monitored
- If heater is used to induce thermal runaway on the cell, a pre-test is run to determine what size heater is required to achieve a ramp rate of $5\pm 2^{\circ}\text{C}/\text{min}$. Alternatively, a closed-loop temperature controller may be used to achieve the ramp.
- If heater is used, cell heater is activated until either thermal runaway is achieved or the cell reaches 200°C , which is held for 20 minutes
- The cell is considered to pass if there is no fire or disassembly

Shipping Li ion Cells and Batteries $\leq 30\%$ SOC

- Li ion cells and batteries are excepted from testing provided that are shipped at $\leq 30\%$ SOC

Test data of Lithium ion cell

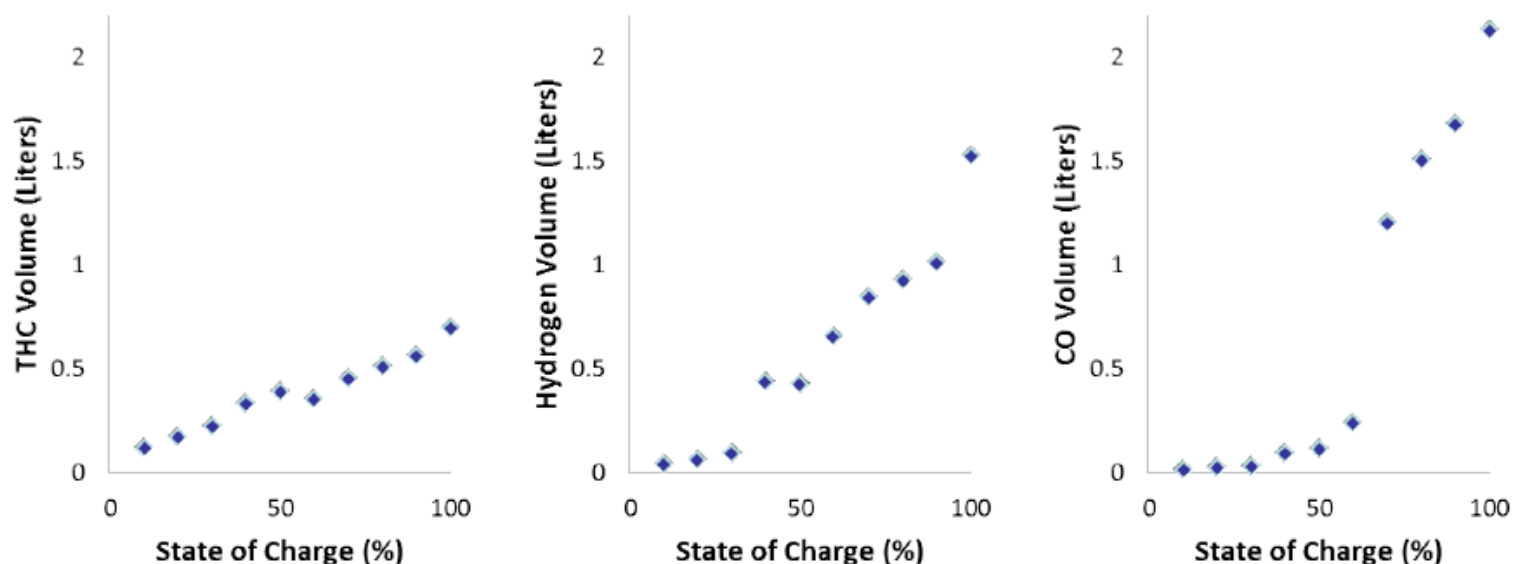
9th – 11th September 2014

BAJ BATTERY
ASSOCIATION OF
JAPAN



FAA Test Data – Gas Generation

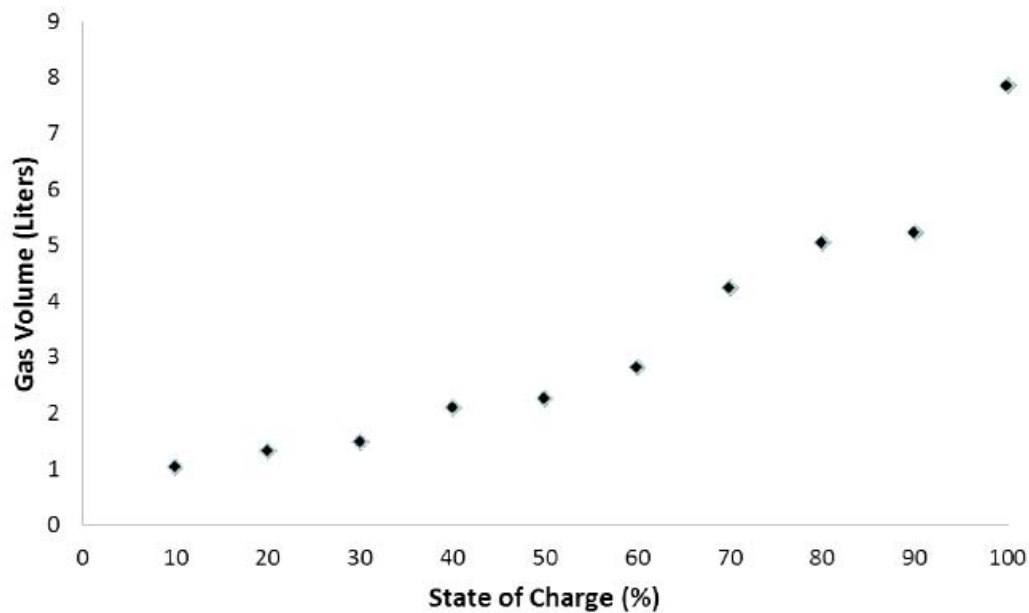
Results - Gaseous Composition



THC, H₂, and CO increased as charge increased.

FAA Test Data - Gas Generation

Results - Gaseous Composition



Total gas volume emitted increases as SOC increases.

Cells, Batteries and Packaging of Similar Design

Cells, batteries or packaging which differ from a tested type by:

- For primary cells and batteries, a change of more than [0.1 g or 20% by mass], whichever is greater, to the cathode, to the anode, or to the electrolyte;
- For rechargeable cells and batteries, an increase in nominal energy in Watt-hours of more than [20%], an increase in nominal voltage of more than [20%], or an increase in state of charge of more than [__%]; or
- A change in packaging configuration that may lead to failure of the test,

shall be considered a new cell, battery or packaging type and subjected to the required tests.

