Lithium Batteries

Fernando MENENDEZ RODRIGUEZ
Panel 5 – Electrical System expert
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Rechargeable Lithium batteries location

- Examples of rechargeable lithium batteries and battery systems:
  - Cockpit displays
  - Brakes
  - Emergency batteries (e.g., EXIT signs)
  - Main batteries
  - Emergency lighting
  - Galley carts (battery pack for pressurization system)
  - New applications…

Non-rech. Lithium batteries location

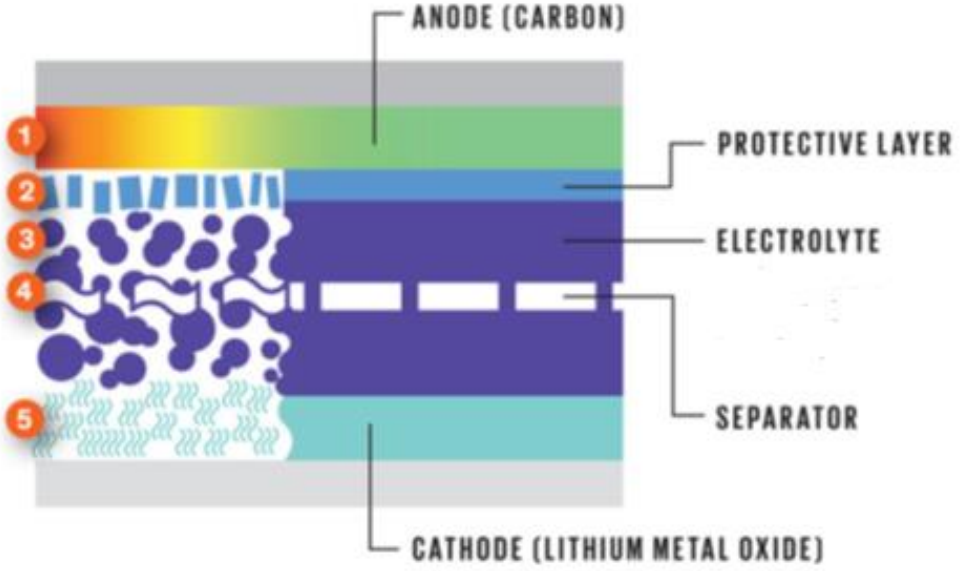
- WHERE?:
  - ELT: emergency locator transmitter
  - Battery packs for emergency lightning
  - Seat bell air bags
  - Flash lights
  - Scape slides
  - CVR: Cockpit voice recorders
  - Flight data recorders
  - Underwater locator beacon
  - Communication management units
  - Cargo tracking devices

- WHY?:
  - Increase in performances requested by new requirements (i.e: ULD: underwater location device requested to be powered 90 days instead of 30)
  - Increase in performances without increasing weight and volume.

Thermal Runaway

- Lithium is the lightest of all metals, has the greatest electrochemical potential and provides the largest specific energy per weight. Batteries with lithium metal on the anode could provide extraordinarily high energy densities.
- However cycling produced unwanted dendrites on the anode. these growth particles penetrate the separator and cause an electrical short. The cell temperature rises quickly and approaches the melting point of lithium, causing thermal runaway, also known as “venting with flame.”

1. Heating starts.
2. Protective layer breaks down.
3. Electrolyte breaks down into flammable gases.
4. Separator melts, possibly causing a short circuit.
5. Cathode breaks down, generating oxygen.



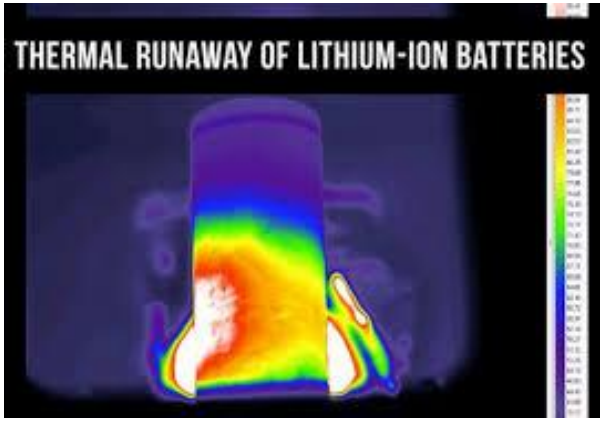
Thermal Runaway

- Four risks can lead to a venting or a thermal runaway, some are due to a failure of the cell by itself, others related to the battery system:
  - Over-charge or over-voltage of the cell (rechargeable batteries)
  - External short circuit of the battery system
  - Exposure to over-temperature
  - Internal short-circuit of the cell (simple or multiple as pin penetration)
- The consequences at cell level is the increasing of temperature and internal pressure, which conducts to venting. The thermal runaway is a long process and occurs when the internal temperature of the cell reaches at minimum 130°C, and corresponds to internal pressure about 10 bars

Thermal Runaway threat demonstration

- Example of short-circuit leading to thermal run away:

- https://youtu.be/HCGtRgBUHX8



Qualification Examples

➢ SHORT-CIRCUIT TEST OF A CELL

To show the effects on a battery or battery system when a cell is subjected to a short circuit condition.

RTCA DO-347 (2013)	RTCA DO-311 (2008)	UL 2054 (2011)	UL 1642 (2015)	UN 38.3	IEC 62281 (2012)	IEC 62133 (2012)	ETSO C-97 (2003)
Short-circuit of R<100mΩ at 55°C for at least 1 hour No debris or flames outside battery No escape emissions other than expected.	✗	✗	✗	✗	✗	Short-circuit of R<80±20 mΩ at 25°C during 24 hours No fire No explosion	✗

Incidents rechargeable Lithium Batteries

7th January 2013, about a minute after all 183 passengers and 11 crew members from Japan Airlines Flight 008 disembarked at Boston's Logan International Airport, a member of the cleaning crew spotted smoke in the aft cabin of the Boeing 787-8.

A mechanic then opened the aft electronic equipment bay of the plane, parked at the airport gate, and saw billowing smoke and flames coming from the batteries for the 787's auxiliary power unit (APU). He tried to use a fire extinguisher, but the blaze didn't go out.

Incidents rechargeable Lithium Batteries

16th January 2013, a Boeing 787-8, operated by All Nippon Airways Co., LTD., took off from Yamaguchi Ube Airport for Tokyo international Airport. When it was climbing through 32,000 ft, an EICAS message of battery failure came on accompanied by unusual smell in the cockpit. The airplane diverted to Takamatsu Airport.

Four passengers out of 137 occupants suffered minor injuries during the evacuation. Although the main battery was damaged, it did not lead to a fire.

Incidents Non-rechargeable Lithium Batteries

Newspaper publication:

- Investigators are calling for a safety review of al lithium battery-powered equipment on planes after a fire on board a parked Boeing 787 at Heathrow, which crew would have struggled to contain in flight, was traced to a tracking device carrying such batteries.

- The blaze, on board the empty Ethiopian Airlines jet in July 2013, burned through the fuselage and filled the cabin with acrid smoke while the plane was on ground.
- Britain's Air Accident Investigations Branch (AAIB) said that while the fire was caused by the plane's lithium battery-powered emergency locator transmitter (ELT), there were concerns other on-board equipment powered by similar batteries may be vulnerable.
- Its investigation found the ELT's battery wires were "crossed and trapped" under the battery compartment cover plate, which probably created a short circuit that caused an uncontrollable increase in temperature, leading to rupture and fire emitting toxic fumes.

Regulation not addressing all Lithium hazards

- Some events leads to discover that regulation in place was not sufficient:
  - Step 1: Authorities need to cover gap regulation: New special conditions raised as per Part 21A.16B
  - Step 2: New guidance material is needed (Minimum Operation Performance Standards):
    - DO-311A for rechargeable Lithium batteries published Dec 2017(RTCA SC-225)
    - DO-227A for non-rechargeable Lithium batteries published Sept 2017 (RTCA SC-235)
  - Step 3:
    - TSO C-142b & C-179b published in March 2018.
    - ETSO C-142b & C-179b to be published in 2019
  - Long term: Requirement 25.1353 & 29.1353 will be updated to be generic. New technologies will be managed by AMC.

Rechargeable Lithium batteries SC

- EASA SC public consultation in 2006.
- EASA implement the SC through a generic Rechargeable Li bat CRI.

- Means of compliance:
  - DO-311A + Risk assessment at A/C level is an acceptable means of compliance with these requirements. Applicable to all sizes of batteries.
- Applicable for A/C types under CS 23, 25, 27 & 29.

- CS-23/27 applies only to “Main batteries”. Further applicability is under discussion. Risk based approach.
- CS-22, VLA, SLA specific SC published in January 2016

https://www.easa.europa.eu/documents/public-consultations/proposed-special-condition-sc-ela2015-01

Rechargeable Lithium batteries ETSO

- ETSO-C179b: Permanently Installed Rechargeable Lithium Cells, Batteries and Battery Systems ➔will reference to DO-311A.

- TSO C-179b published On March 2018
- ETSO C-179b will be published in 2019.

- New ETSO applications will be requested to comply with DO-311A.

- New installations will be requested to comply with the Special Conditions

Non-Rechargeable Lithium batteries SC

- Part 21A 16B: EASA published September 2016 the Special Conditions.

  https://www.easa.europa.eu/system/files/dfu/SC%20F-xx%20Issue%201.pdf

- EASA implement the SC through a generic Non-rechargeable Li bat CRI to CS25 & CS29 products.

- CS-23/27 applicability is under discussion. Risk based approach.

- Previous Means of Compliance: Due to missing a more appropriate standard, **ETSO-C142a** + **Risk assessment at A/C level** is an acceptable MoC to the SC contained in this CRI.
- In parallel FAA created IP (SC & MoC) for this topic.
- FAA MoC TSO 142a + DO 347 “Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Batteries and Battery Systems” (testing)

NRLB: Clarifications to MoC

- **Minimum Operational Performance Standards (MOPS) for Non–Rechargeable Lithium Batteries DO-227A + risk assessment at A/C level (limited to Special Conditions 3, 4, 5 & 6) is an acceptable MoC to the Special Conditions 1 to 6 contained in this CRI.**

- Alternatively Means of Compliance can be proposed by the applicant to show compliance with the SC's included in this CRI and agreed by EASA in a case by case basis.

- Risk assessment at A/C level:
  - Cover the delta between qualification and safe functioning & installation.
  - Internal failures can occur!!! Mitigation means to be presented.
  - Understand the impact on the rest of the A/C, crew & passengers.

Non-Rechargeable Lithium batteries ETSO

- ETSO C-142b will be published in 2019
- TSO C-142b published March 2018

- New ETSO applications will be requested to follow the new material DO-227A.

- Batteries between 2 & 5W.h have an special treatment. TSO-C142b-7 approvals. End item level test.

- New installations will be requested to comply with the Special Conditions

Very small batteries treatment

- For Very Small Lithium Batteries (equal or less than 2 Watt-hour of energy), an acceptable Means of Compliance with this Special Condition is showing these batteries compliant with Underwriters Laboratories UL 1642, UL 2054 (only rechargeable) & IEC 62133 (only rechargeable).

- EASA CRI Rechargeable & Non rechargeable Li bat does not apply to “very small batteries” qualified as per above if qualification is referenced in the Certification Plan.

EASA
European Aviation Safety Agency

Thank you.

Questions ?

Your safety is our mission.

An agency of the European Union