FIRE CONTAINMENT COVER

LITHIUM ION BATTERY FIRE TESTS

International Aircraft Systems Fire Protection Working Group Meeting
Oct 21-22 2015

Shakir Jamaldeen
October 2015
FULL SCALE FCC LI-ION FIRE TEST – SETUP

- FCC with dimensions 121” x 92” x 96” height
- 18650 Li-Ion (Secondary) 2600mAh 3.7V batteries
- Brand new semi-charged direct from manufacturer in original packaging
- Total of 1500 Li-Ion batteries – 9 boxes
- 2 boxes positioned directly beneath FCC roof
- 1 box positioned on 125” side touching FCC side
- 6 boxes positioned in middle immediately above pallet
- Balance volume filled up with cardboard boxes containing shredded paper
- Standard aluminium pallet
- 2 x 100W cartridge heaters at each battery location (6 in total)
- Ignition at all 3 locations simultaneously
- 8 thermocouples positioned on the exterior of the FCC
FULL SCALE FCC LI-ION FIRE TEST – OBSERVATIONS

- Fire successfully contained for 6 hours
- Battery box on front side collapsed against FCC
- Net braid melted where battery box collapsed. Majority intact. No net flaming
- Cardboard seen burning through gaps between FCC and pallet
- All batteries vented
## FULL SCALE FCC FIRE TEST – OBSERVATIONS

<table>
<thead>
<tr>
<th>Thermocouple</th>
<th>Position</th>
<th>Temperature (°C)</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Right Centre - 4”</td>
<td>36.17</td>
<td>97.1</td>
</tr>
<tr>
<td>T2</td>
<td>Back Centre - 4”</td>
<td>42.28</td>
<td>108.1</td>
</tr>
<tr>
<td>T3</td>
<td>Left Centre - 4”</td>
<td>62.68</td>
<td>144.8</td>
</tr>
<tr>
<td>T4</td>
<td>Front Centre - 4”</td>
<td>66.05</td>
<td>150.9</td>
</tr>
<tr>
<td>T5</td>
<td>Roof Centre - 4”</td>
<td>45.32</td>
<td>113.6</td>
</tr>
<tr>
<td>T6</td>
<td>Roof Centre - touch</td>
<td>63.48</td>
<td>146.3</td>
</tr>
<tr>
<td>T7</td>
<td>Front Centre - touch</td>
<td>88.20</td>
<td>190.8</td>
</tr>
<tr>
<td>T8</td>
<td>Pallet Under - touch</td>
<td>76.30</td>
<td>169.3</td>
</tr>
</tbody>
</table>

![Diagram showing thermocouple positions and temperature readings](image-url)
FIRE CONTAINMENT BAG (FCB) LI-ION FIRE TESTS - SETUP

- FCB test within aluminium ULD container
  - Laptop battery details: 11.1 V, 5200mAh, quantity 2
  - Cargo load: 3 cardboard boxes filled with shredded paper
  - Laptop batteries placed in bottom most box

- FCB (damaged) test within composite ULD container
  - FCB damaged to maximum allowable limits
  - Laptop battery details: 11.1 V, 5200mAh, quantity 2
  - Cargo load: 3 cardboard boxes filled with shredded paper
  - Laptop batteries placed in bottom most box
  - FCB surrounded by unprotected combustible cargo
FCB LI-ION FIRE TESTS - OBSERVATIONS

- **FCB test within Aluminium ULD container**
  - Batteries explode/vent at 3:50 min following ignition
  - **Fire successfully contained**
  - *Two large fabric sections of the FCB were cut out to allow for ventilation. Fire reignited and test continued for 3 hours.*
  - All batteries had exploded/vented
  - Aluminium container was not affected by fire

- **FCB (damaged) test within composite ULD container**
  - Batteries explode/vent at 1:15 min following ignition
  - **Fire successfully contained**
  - All batteries had exploded/vented
  - Composite container and unprotected boxes were not affected by fire
SUMMARY OF RESULTS

FCC Lithium-ion fire test
- FCC contained Li-ion battery fire for 6 hours
- All cells experienced thermal runaway
- Temps measured outside did not exceed 90°C (194°F)

FCB Lithium-ion fire test in aluminium container
- FCB contained Li-ion battery fire
- All batteries experienced thermal runaway

Damaged FCB Lithium-ion fire test in composite container
- FCB contained Li-ion battery fire
- All batteries experienced thermal runaway
- No damage to container or surrounding boxes
Thank you for your time