Passive Fire Protection for Lithium Battery Shipments

Presented to: Systems Meeting
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Date: 05-15-2014
Background

- Lithium batteries have been the cause of fires in small personal electronic devices and larger “bulk” quantities and continue to grow in popularity and use.
  - Small-scale incidents
    - Approximately 64 cargo/baggage incidents have been recorded by the FAA since 1991. [3]
  - Incidents involving large quantities of cells
    - Batteries contributed to an accident in Dubai in 2010. [2]
    - An aircraft fire involving lithium batteries occurred in 2006. [1]
    - Numerous lithium-ion car fires have occurred.
Objective

• Vary the separation distance between each cell with standard cardboard packaging.
  – Determine how the separation distance effects propagation time.
  – Determine how the separation distance effects cell temperatures.
Previous Tests

• A variation of the state-of-charge of the Li-Ion cells effected thermal runaway propagation.
  – With standard cardboard packaging, 18650 cells at 30% failed to propagate.
  – At higher states-of-charge, propagation time decreased and average temperatures increased.

• A variation in cell divider materials was shown to effect the propagation of cells.
  – Insulative packaging materials slowed thermal-runaway propagation rate and decreased the temperatures.
  – Conductive materials delayed the time to thermal runaway but decreased the propagation time.

• A packet of water above the cells stopped propagation.
• Explosions of cells stopped propagation.
Setup (packaging)

- Tests were conducted within a 64 ft³ chamber with a constant ambient air temperature.
- Tests were performed in battery boxes with a 16 cell capacity and a thermocouple on each cell.

- One of the 16 cells was replaced with a cartridge heater which was used to initiate thermal-runaway in the adjacent cells.
Tests Performed (packaging)

<table>
<thead>
<tr>
<th>State of Charge</th>
<th>Two sheets of cardboard (.3” thick)</th>
<th>Three sheets of cardboard (.45” thick)</th>
<th>Five sheets of cardboard (.75” thick)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td></td>
<td></td>
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</table>

![Image of packaging tests]
Results

• Larger separation distances were not very effective at reducing cell temperatures.
• Separation distance did however have a significant impact on the rate of propagation.
Summary

• Larger separation distances decreased the propagation rate.
  – Recent ICAO recommendations of 8 cells per package (greater separation distance) would increase the amount of time that a pilot has to react to a fire.

• Larger separation distances have little effect on the temperatures of the cells.
  – Maximum cell temperatures for lithium-ion cells are not “strongly” dependent on rate of heating.
  – Recent ICAO recommendations of 8 cells per package (greater separation distance) would not have much effect on the heat release per cell.
Questions?

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Citations

