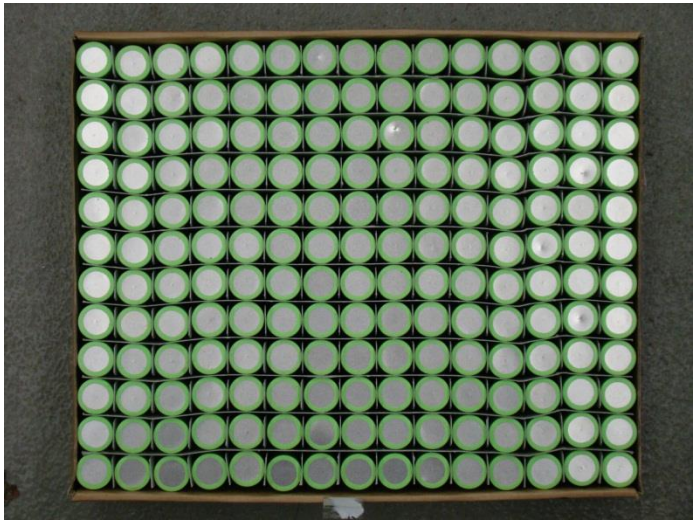
Passive Fire Protection for Lithium Battery Shipments

Federal Aviation Administration



Presented to: Systems Meeting

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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

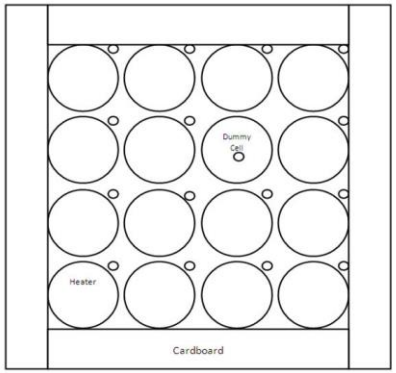
- **Vary the separation distance between each cell with standard cardboard packaging.**
  - Determine how the separation distance effects propagation time.
  - Determine how the separation distance effects cell temperatures.

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)

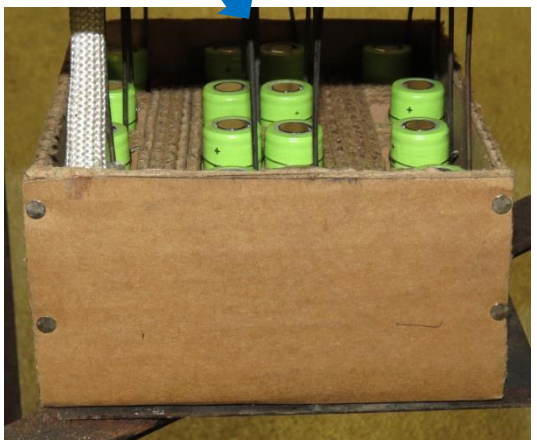
- **Tests were conducted within a 64 ft³ chamber with a constant ambient air temperature.**
- **Tests were performed in battery boxes with a 16 cell capacity and a thermocouple on each cell.**



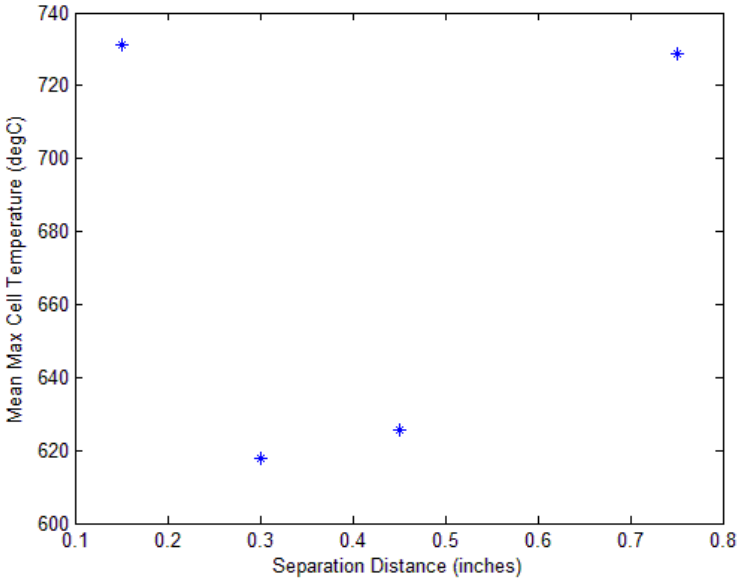
- **One of the 16 cells was replaced with a cartridge heater which was used to initiate thermal-runaway in the adjacent cells.**

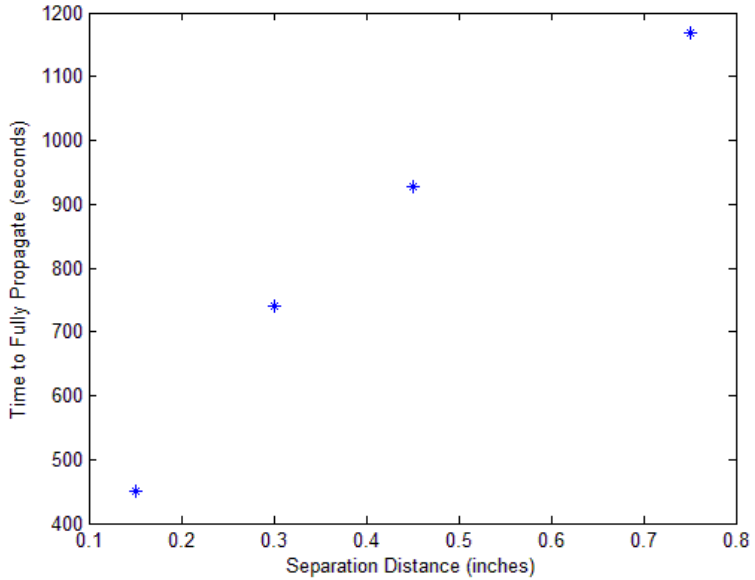
Tests Performed (packaging)

State of Charge	Two sheets of cardboard (.3” thick)	Three sheets of cardboard (.45” thick)	Five sheets of cardboard (.75” thick)
60%			



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

- **[1] Thurber, Matt. "Cargo Carriage of Lithium Batteries Suspected in Some Accidents." *AINonline*. Aviation International News, Feb. 2012. Web. 01 Nov. 2012. <http://www.ainonline.com/aviation-news/aviation-international-news/2012-02-01/cargo-carriage-lithium-batteries-suspected-some-accidents>.**
- **[2] "Air Accident Investigation Interim Report." General Civil Aviation Authority, n.d. Web. 1 Nov. 2012. <http://www.gcaa.gov.ae/en/ePublication/admin/iradmin/Lists/Incidents%20Investigation%20Reports/Attachments/16/2010-Interim%20Report%20B747-400F%20-%20N571UP%20-%20Report%2013%202010%20-%20Rev%201.pdf>.**
- **[3] "BATTERIES & BATTERY-POWERED DEVICES." FAA Office of Security and Hazardous Materials Safety, n.d. Web. 1 Nov. 2012. <http://www.faa.gov/about/office_org/headquarters_offices/ash/ash_programs/hazmat/aircarrier_info/media/Battery_incident_chart.pdf>.**