Lithium Battery Update
Full Scale Tests
Air Exchange Baseline

Presented to: Systems Working Group
By: Harry Webster, FAA
Date: November 15, 2012
Full Scale Fire Tests
Objective

• To document the characteristics of large battery fires in a realistic aircraft environment.
• With Suppression-Class C
• No Suppression-Class E
Full Scale Fire Test Plan

• Baseline
• Class E Cargo
  – Lithium-ion 5000 18650 cells
  – Lithium metal 4800 SF123A Cells
  – 5000 mixed alkaline, NiCad, NiMH
Full Scale Fire Test Plan

- Class C Cargo w/ Halon 1301 Suppression
  - Lithium-ion 5000 18650 cells
  - Lithium-metal 4800 SF123A cells
  - 5000 mixed alkaline, NiCad, NiMH
Instrumented 727 Test Article
Instrumentation: Class E

- Two trees
  - Thermocouples
  - Calorimeter
  - Smoke meter
  - Gas measurement – CO, CO2, O2
  - Compartment pressure

- Ceiling T/C’s
  - 6” below cargo liner
  - Above cargo liner in vicinity of fire

- Video
  - cameras, infrared
Instrumentation: Flight Deck

– One instrumentation tree
  - Thermocouples
  - Smoke density meter
  - Gas measurement
  - Pressure

– Video
  - Overall
  - Smoke detector panel
Instrumentation: Class C

- Instrumentation tree
  - Thermocouples
  - Calorimeter
  - Smoke density
  - Gas measurement
  - Compartment pressure

- Ceiling T/C’s above and below the cargo liner
Instrumentation: Battery Stack

– Distributed thermocouples
  • Track progress of thermal runaway

– Cartridge heater thermocouple

– Calorimeter
  • Above center of fire load
Aircraft Ventilation

- Airflow patterns within the aircraft can have significant impact on the behavior of the battery fire and smoke penetration.
- The aircraft air packs are configured differently depending on the location of the fire.
- Two configurations were developed with input from the Boeing Company (Thanks Doug!), one for the maid deck class E fire and one for the forward class C compartment.
Aircraft Ventilation Settings

Class E Depressurized

- **Aircraft Flight Manual**
  - RH pack ON
  - LH pack OFF
  - The Cabin Air Distribution Lever is put in the AIR SHUTOFF position.
  - The Gasper Fan is OFF
  - The Cargo Heat Outflow is NORMAL
  - The Cockpit air conditioning outlets and gasper outlets are OPEN
  - The Passenger Cabin Temp Selector is MANUAL (as required)

- **Additional Settings**
  - External air conditioner flow adjusted to simulate single pack airflow
  - Avionics cooling fan ON
  - Outflow valves closed

Class C Pressurized

- **Aircraft Flight Manual**
  - The Cargo Heat Outflow is CLOSED
  - Single Pack Operation – Do not depressurize
  - The Cabin Air Distribution Lever is put in FULL OPEN

- **Additional Settings**
  - Outflow valves chocked open ¼”
  - Avionics cooling fan ON
  - External air conditioner set to “wide body” to maintain 0.5 psi differential across the fuselage
Conducted Air Exchange Tests
Air Exchange Test Procedures

- Air exchange tests were conducted in the main deck cabin (class E) and the flight deck. The class C tests will be conducted at a later date.
- Tests were conducted in each Airflow configuration, pressurized and unpressurized
- CO2 was discharged into each compartment and the concentration decay rate was measured. Fans insured uniform mixing.
Air Exchange Rate Results

• Pressurized configuration
  – Main deck cabin: 5.75 minutes per air change
  – Flight deck: 1.68 minutes per air change

• Unpressurized configuration
  – Main deck cabin: 47.72 minutes per air change
  – Flight deck: 1.71 minutes per air change
Conducted Baseline Test
Baseline Test

• **Purpose:**
  – To insure operational status of all instrumentation
  – Validate airflow patterns
  – Provide a comparison class A fire for later battery tests

• **Fire load**
  – Four 18”x18”x18” cardboard boxes filled with shredded paper

• **Ignition:** NiChrome wire

• **Results:** Under Analysis
Contact Information

Harry Webster
609-485-4183
Harry.Webster@faa.gov
www.fire.tc.faa.gov