An Overview of FAA Aircraft Fire Safety R&D Since the Previous Triennial Conference

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Aircraft Fire Safety: 
Areas of Concern

Postcrash Fire  
In-flight Fire

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The Fire Safety Program Addresses:

• In-flight fire threats
  – Accident prevention
  – Accident mitigation
• Post-crash fire threats—principally mitigation
• Improving fire safety through improved technologies and materials
• Ensuring fire safety is not degraded as a result of new/novel technologies and materials
Hidden Fire Protection

- **Passive**: Evaluate the fire hazards of materials in inaccessible areas when exposed to a standard fire and, if needed, develop new flammability test methods.

- **Active**: Evaluate detection techniques and extinguishment systems (fixed and hand-held) for controlling fires in inaccessible areas.

- **Drivers**:
  - Swiss Air MD-11 accident / TSB recommendations
  - Cabin/Cockpit smoke and odor incidents (US: ~900/year)
  - NTSB recommendations
Hidden Fire Protection

• **Major Accomplishments:**
  – Developed and standardized improved flammability test methods and criteria for A/C ducting and electrical wiring.
  – Issued In-Flight Hidden Fire Fighting Training Video (FAA INFO, June 23, 2009)
Large-Scale Test Configuration for Measuring Flammability of Insulation Blankets
## ELECTRICAL WIRES/CABLES FIRE TEST RESULTS

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Wire ID</th>
<th>Temperature Rating</th>
<th>FAA 60 Degree Flammability Wire Test</th>
<th>Intermediate-Scale Fire Test</th>
<th>30 Degree Radiant Heat Panel Test</th>
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<tbody>
<tr>
<td>1</td>
<td>CAT3 Cable</td>
<td>60</td>
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<td>4</td>
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<td>5</td>
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<tr>
<td>6</td>
<td>Fiber Optic Riser Cable</td>
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<td>Hypalon</td>
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<tr>
<td>8</td>
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<td>9</td>
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<td>10</td>
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<tr>
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<tr>
<td>14</td>
<td>MS81044/6</td>
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<tr>
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<td>21</td>
<td>Silicone</td>
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<td>Failed</td>
<td>Failed</td>
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<td>22</td>
<td>MS22759/86</td>
<td>260</td>
<td>Passed</td>
<td>Passed</td>
<td>Passed</td>
</tr>
</tbody>
</table>

Wire temp rating also based on conductor material and coatings: annealed/high strength copper with tin/silver/nickel coatings.
• On this horizontal surface, place the specimen holder so that the wire bundle specimen is 3±1/16 (7.62±0.16 cm) inches away from the radiant heat panel and clears the pilot burner.
Halon Replacement

- Evaluate potential replacement agents and systems and provide technical guidance for the safe conversion to environmentally friendly fire suppression and extinguishing agents for use on aircraft.

- **Drivers:**
  - ICAO mandate to replace halon (proposed)
  - European Commission phase-out of halon (draft, but includes retrofit)
  - Halon contamination
Halon Replacement

• **Major Accomplishments:**
  - Completed Study and Published Report “Guidelines for Safe Use of Gaseous Halocarbon Extinguishing Agents in Aircraft”
  - Completed MPS for Engines/APU’s Revision 04 (non-gaseous agents).
Halon Replacement

Kinetic Model of Halocarbon Transport in the Body
Halon Replacement

COMPARISON OF KINETIC MODEL TO PBPK DATA FOR HUMAN ARTERIAL BLOOD CONCENTRATION HISTORY OF HCFC-123 DURING EXPOSURE TO $A_0 = 1.26\% \text{ v/v (79 mg/L)}$. 
Halon Replacement

MPSₐ rev04 Completed
High Energy Power Source Fire Hazards

• Determine the fire hazards and methods for control of high energy lithium batteries and fuel cells.

• Applications: bulk transport as cargo, carriage in passenger baggage, carriage and use in the cabin and aircraft design or equipment.

• Drivers:
  – 44 aircraft lithium battery fires since 1991
  – 3.3 billion lithium cells transported worldwide in 2008
  – PHMSA proposed rule (in consultation with FAA)
High Energy Source Fire Hazards

• Major Accomplishments:
  – Completed testing/video on fighting fires caused by lithium batteries in laptops (SAFO, June 23, 2009).
  – Evaluated the fire hazard characteristics of prototype fuel cells (published technical report).
  – Evaluated the fire hazard characteristics of lithium cells in proposed aircraft battery systems (published technical report).
  – Initiated lithium battery cargo container tests.
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Battery Types

- Three battery manufacturers have submitted cells for testing

<table>
<thead>
<tr>
<th>Battery Type</th>
<th>Battery Cell #1</th>
<th>Battery Cell #2</th>
<th>Battery Cell #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Size</td>
<td>Cylindrical Li-ion</td>
<td>Cylindrical Li-ion</td>
<td>Li-Polymer</td>
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<tr>
<td>Chemistry</td>
<td>18650*</td>
<td>26650*</td>
<td>3 ½” x 4” x ¼”</td>
</tr>
<tr>
<td>Capacity (mAh)</td>
<td>1150</td>
<td>2300</td>
<td>8000</td>
</tr>
</tbody>
</table>

* Cylindrical Battery Size Notation: First two digits are cell diameter in mm, next three digits are cell height in mm
Battery Cell Testing

Autoignition Test Results

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th></th>
<th>Trial 2</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Ignition Temp (F)</td>
<td>Peak Temp (F)</td>
<td>Ignition Temp (F)</td>
<td>Peak Temp (F)</td>
</tr>
<tr>
<td>Cell Type #1</td>
<td>440</td>
<td>572</td>
<td>490</td>
<td>649</td>
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<tr>
<td>Cell Type #2</td>
<td>480</td>
<td>664</td>
<td>527</td>
<td>639</td>
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<tr>
<td>Cell Type #3</td>
<td>340</td>
<td>741</td>
<td>330</td>
<td>788</td>
</tr>
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</table>
Lithium-Ion Batteries

Bulk Load Configuration before Testing
Lithium-Ion Batteries

Bulk Load Configuration after Testing
Post Crash Burn-through Protection

• Development of guidance material and support for transport airplane burn-through requirement (Effective 9/2/09).

• Drivers:
  – Impending complex insulation burnthrough resistance rule
  – Unavailability of Park Burner referenced in rule
Post Crash Burn-through Protection

• Major Accomplishments
  – Development of the Next Generation or “NexGen” burner as an equivalent test method for demonstrating compliance with insulation burnthrough rule, FAR 25.856
  – Development of guidance for installation details and techniques to realize full potential of burnthrough resistant insulations, contained in Advisory Circular 25.856-2A
  – Development of a small-scale test method for measuring gas emissions accumulated from burnthrough-resistant fuselage materials
NexGen Burners
Testing Results – Picture Frame

Average B.T. Times for 4 Materials on Picture Frame Blanket Holder

<table>
<thead>
<tr>
<th>Material Type</th>
<th>FAATC Park</th>
<th>Boeing NG6</th>
<th>FAA NG4</th>
<th>FAA NG5</th>
<th>FAA NG1</th>
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<tr>
<td>19394-8611R</td>
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<td>211</td>
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<td>19395-8611R</td>
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<tr>
<td>19391-8579R</td>
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<td>185</td>
<td>186</td>
<td>177</td>
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<td>183</td>
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<td>175</td>
<td>184</td>
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</table>
Full-Scale Test Results, Structural Composite System During Test
Full-Scale Test Results, Structural Composite System

Post-Test
Fire Safety of New Material Technology

• Determine the adequacy of present regulations and advisory material as it applies to new technology materials in aircraft (e.g., composite fuselage and wings)

• Where necessary, develop new test protocols and/or guidance materials.

• Drivers:
  – New test methods would obviate the need for Special Conditions in new composite aircraft
  – New lightweight magnesium alloys are fire resistant
Fire Safety of New Material Technology

• Major Accomplishments:
  – Evaluated impact on postcrash fire survivability of magnesium alloy seat structure under full-scale fire test conditions
  – Developed a new flammability test method and criteria that measures the in-flight fire resistance of composite fuselage materials
AZ-31 Test Configuration
AZ-31 Test Results
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Freighter Fire Safety

- Determine the adequacy of current fire safety requirements in freighter aircraft and the feasibility and cost/benefit of fire detection and suppression improvements.

- Drivers:
  - Freighter hull losses and serious incidents caused by fire
  - NTSB recommendations related to (1) adequacy of current detection means and (2) need for an on-board fire suppression system
Freighter Fire Safety

• **Major Accomplishments**:  
  – Completed a cost-benefit analysis for the installation of a fire detection and suppression system (Halon total flood) in freighter aircraft (Technical report published).
  – Determined the effect of depressurization on the burning behavior of materials (Technical report drafted).
  – Demonstrated the adequacy of certification tests employed to demonstrate compliance with freighter detection response criteria (Technical report published).
Freighter Fire Safety

Cost

- Fuel, 30%
- Liner Installation, 45%
- System Installation, 24%
- System Development, 0.1%
- Liner Development, 0.2%
- Maintenance, 2%

Benefit

- Aircraft, 58%
- Cargo, 11%
- Crew Fatal, 24%
- Crew Serious, 2%
- Collateral, 5%
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Main Deck Airflow approximately one air change every 5.1 minutes (11.8 air changes/hour). Air from one pack supplied with APU bleed air.
727 Main Deck

Detection Time (seconds)

Position

- Empty Detection Time
- Full Detection Time
Fuel Tank Flammability/Protection

- Study and compare the fuel vapor flammability of composite and aluminum wing fuel tanks under ground and simulated flight conditions.
- Support implementation of new fuel tank flammability reduction rule.
- Drivers:
  - Lack of composite fuel tank flammability data
  - Fuel Tank Flammability Assessment Method (FTFAM, or “Monte Carlo Model”) is used to determine fuel tank flammability as required by FAR 25.891
Fuel Tank Flammability/Protection

- **Major Accomplishments:**
  - Evaluated and compared fuel vapor flammability of composite and aluminum wing fuel tanks under simulated flight conditions
  - Published Fuel Tank Flammability Assessment Method Users Manual
Test Apparatus – Airflow Induction Test Facility

- Test article was mounted in the high speed test section
  - 5-½ foot in diameter and 16 feet in length.

- Maximum airspeed of approximately 0.9 mach, though with the test article we measured airspeeds of approximately 0.5 mach
Regulatory & Industry Support Interface

• This project supports both regulators and industry in solving problems encountered with present requirements/advisory material.
• Provides an interface for fire safety R&D with other agencies, international authorities and industry.
• Supports fire accident/incident investigation.
• Drivers:
  – Complexity of material fire test standards and inherent variability in fire behavior
  – Need for cooperation and coordination to pool resources and knowledge
Summary of Rules and Guidance Related to Fire Safety R&D

- Fuel Tank Flammability Reduction Rule (2008)
- Installation of Burnthrough Resistance Insulation AC (2008)
- Flammability Testing of Lightweight Seats Policy Memo (2009)
- In-Flight Fire Fighting INFO (2009)
- Laptop/Lithium Battery Fire Fighting SAFO (2009)
- Burnthrough Resistance Insulation Rule (2009)
- Fire Safe Transportation of Lithium Batteries (Pending)