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

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The 6th Triennial Fire & Cabin Safety Research Conference
Tropicana Casino Resort; Atlantic City, NJ
October 25 – 28, 2010

Federal Aviation Administration

Aircraft Fire Safety:
Areas of Concern

Postcrash Fire

In-flight Fire

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

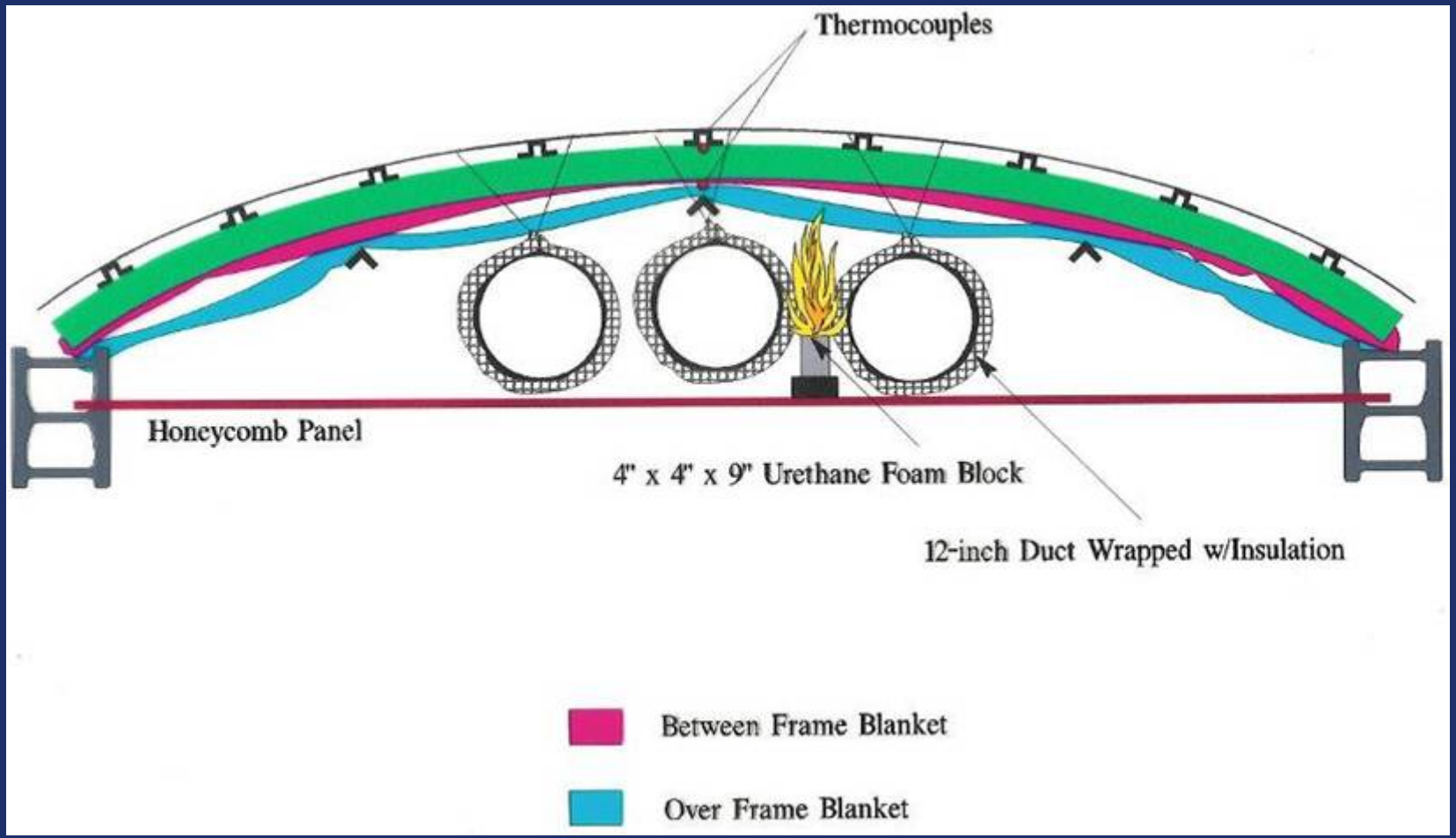
Hidden Fire Protection

- **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



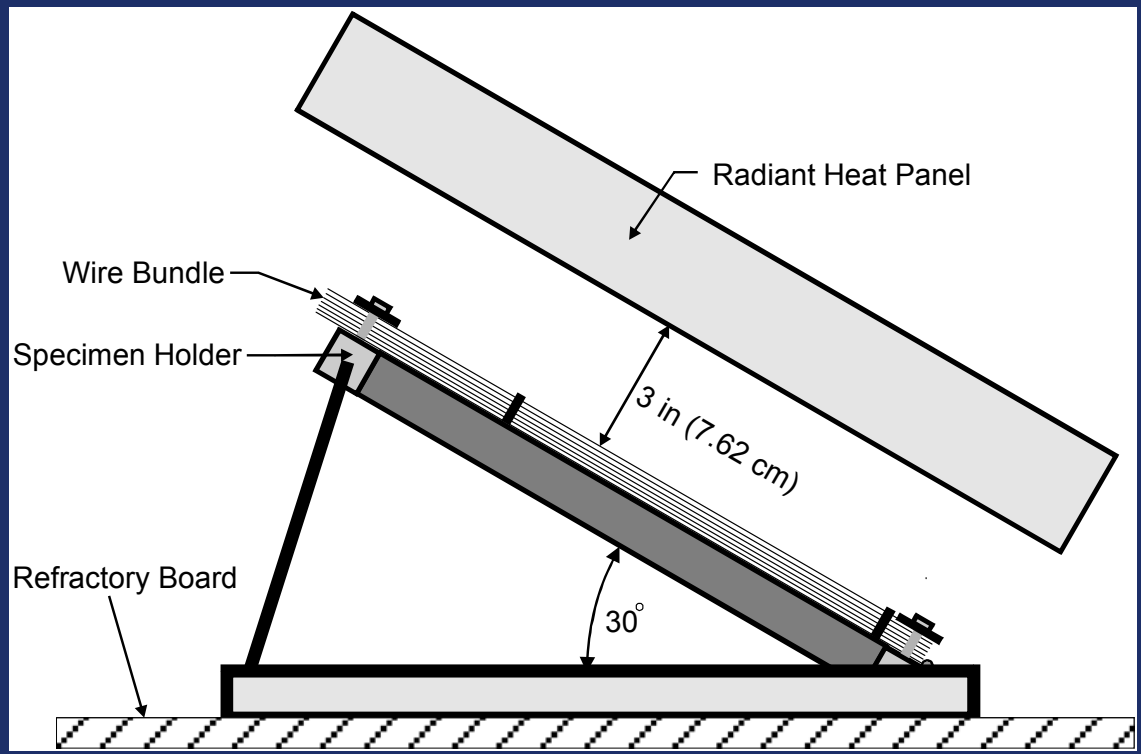
Aircraft Wiring Test Development

ELECTRICAL WIRES/CABLES FIRE TEST RESULTS

Item No.	Wire ID	Temperature Rating	TEST		
			FAA 60 Degree Flammability Wire Test	Intermediate-Scale Fire Test	30 Degree Radiant Heat Panel Test
1	CAT3 Cable	60	Passed	Failed	Failed
2	CAT5e Cable	60	Passed	Failed	Failed
3	Computer Cable	60	Passed	Failed	Failed
4	M17/28-RG58	80	Passed	Failed	Failed
5	Neoprene	90	Passed	Failed	Failed
6	Fiber Optic Riser Cable	105	Passed	Failed	Failed
7	Hypalon	105	Passed	Failed	Failed
8	MS5086/1	105	Failed	Failed	Failed
9	MS22759/14	135	Passed	Passed	Passed
10	BMS13-48	150	Passed	Passed	Passed
11	BMS13-60	150	Passed	Passed	Passed
12	MS22759/16	150	Passed	Passed	Passed
13	MS22759/32	150	Passed	Passed	Passed
14	MS81044/6	150	Passed	Passed	Passed
15	MS81381/21	150	Passed	Passed	Passed
16	BMS13-55	200	Passed	Passed	Passed
17	BMS13-72	200	Passed	Passed	Passed
18	MS22759/11	200	Passed	Passed	Passed
19	MS22759/33	200	Passed	Passed	Passed
20	MS22759/5	200	Passed	Passed	Passed
21	Silicone 200	200	Failed	Failed	Failed
22	MS22759/86	260	Passed	Passed	Passed

Wire temp rating also based on conductor material and coatings: annealed/high strength copper with tin/silver/nickel coatings

Test Apparatus



- 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.

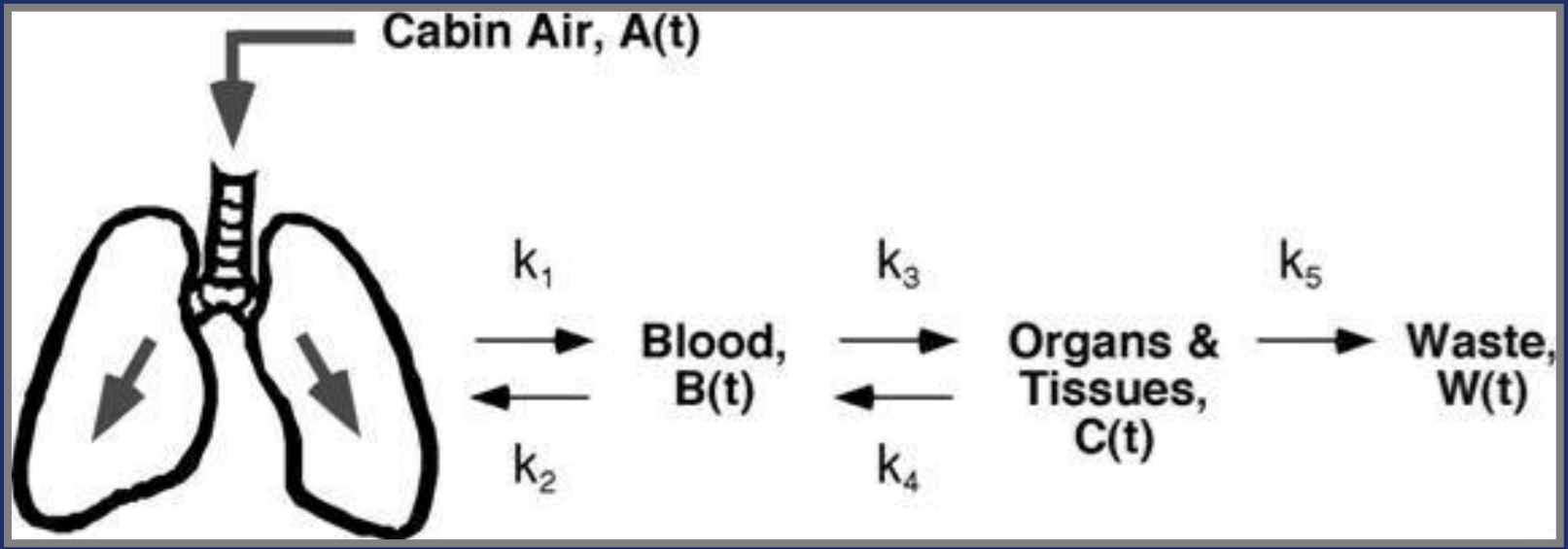
Halon Replacement

- **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

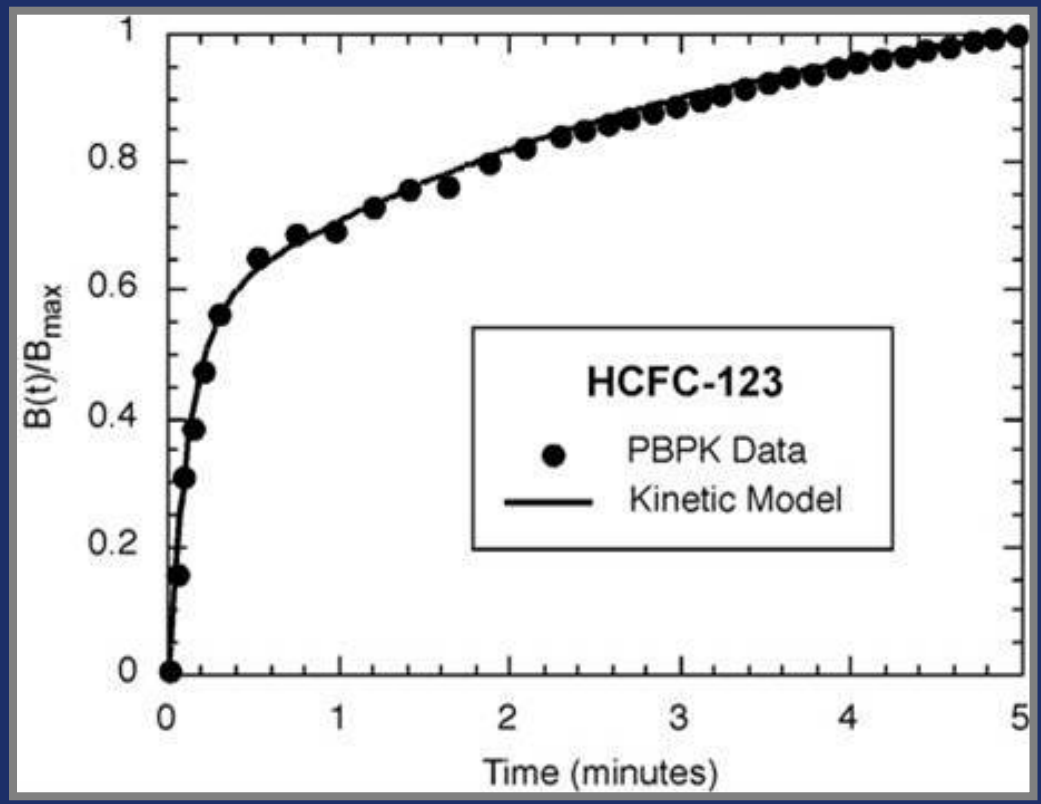
- **Major Accomplishments:**
  - Completed Study and Published Report “Guidelines for Safe Use of Gaseous Halocarbon Extinguishing Agents in Aircraft”
  - Completed MPS for Engines/APU’s Revision 04 (non-gaseous agents).

Halon Replacement



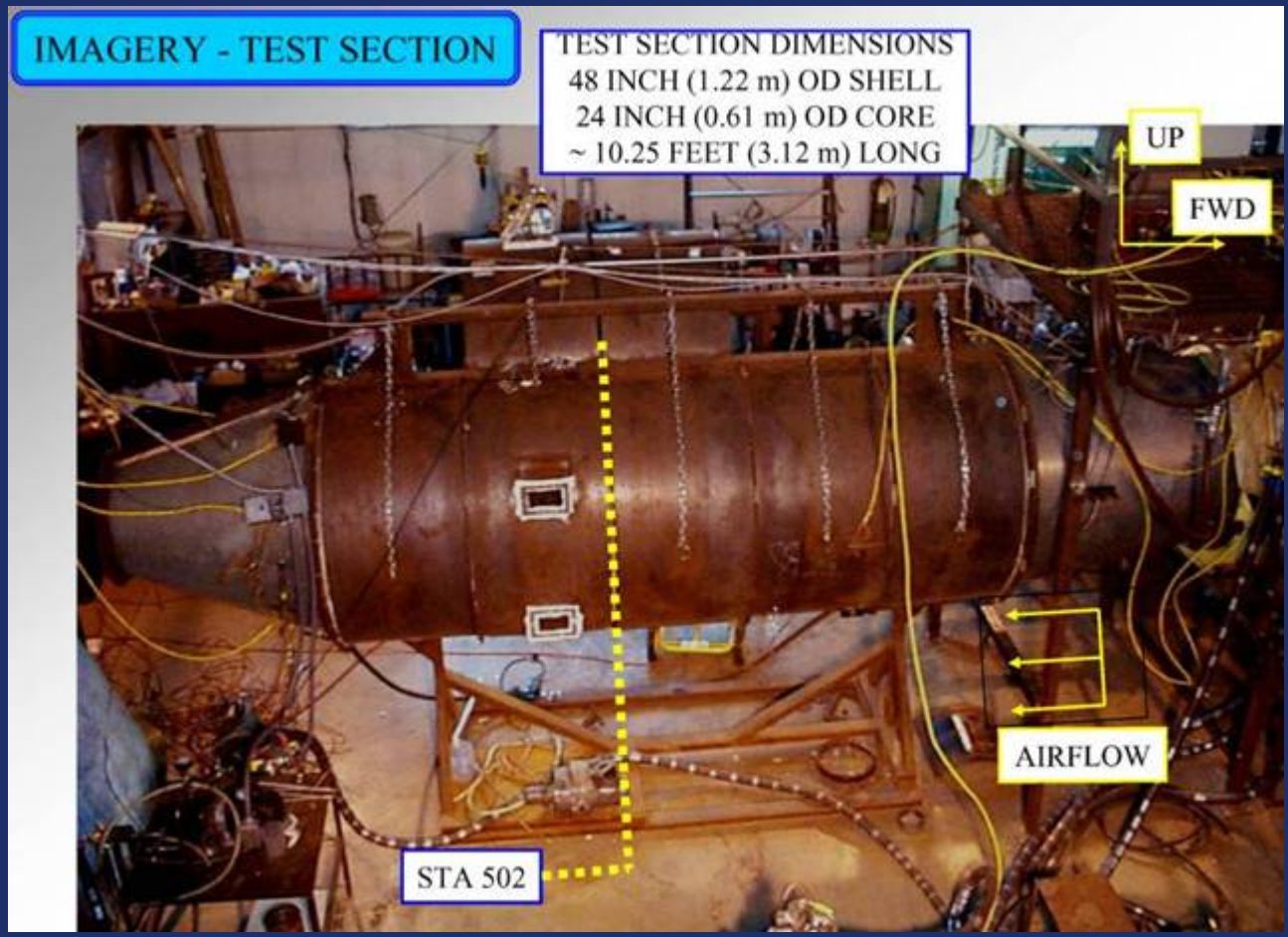
Kinetic Model of Halocarbon Transport in the Body

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% v/v (79 mg/L).

Halon Replacement



MPS_e 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.

SAFO

Safety Alert for Operators

U.S. Department
of Transportation

**Federal Aviation
Administration**

SAFO 09013
DATE: 6/23/09

Flight Standards Service
Washington, DC

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo

A SAFO contains important safety information and may include recommended action. SAFO content should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest possible degree of safety in the public interest. Besides the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO.

Subject: Fighting Fires Caused By Lithium Type Batteries in Portable Electronic Devices

Purpose: To recommend procedures for fighting fires caused by lithium type batteries in portable electronic devices (PED).

Background: The two types of batteries commonly used to power consumer PEDs brought on aircraft are lithium batteries (disposable) and lithium-ion batteries (rechargeable). Both these types are capable of ignition and subsequent explosion due to overheating. Overheating results in thermal runaway, which can cause the release of either molten burning lithium or a flammable electrolyte. Once one cell in a battery pack goes into thermal runaway, it produces enough heat to cause adjacent cells to go into thermal runaway. The resulting fire can flare repeatedly as each cell ruptures and releases its contents.

Discussion: Based on testing by the Fire Safety Branch of the Federal Aviation Administration (FAA) William J. Hughes Technical Center, the following procedures are recommended for fighting a fire of a lithium-type-battery powered PED. The procedures consist of two phases: (1) extinguishing the fire, and (2) cooling the remaining cells to stop thermal runaway.

(1) Utilize a Halon, Halon replacement or water extinguisher to extinguish the fire and prevent its spread to additional flammable materials.

(2) After extinguishing the fire, douse the device with water or other non-alcoholic liquids to cool the device and prevent additional battery cells from reaching thermal runaway.

WARNING: Do not attempt to pick up and move a smoking or burning device! Bodily injury may result.

WARNING: Do not cover the device or use ice to cool the device. Ice or other materials insulate the device, increasing the likelihood that additional battery cells will reach thermal runaway.

Reference Materials: The following are additional information related to lithium-type battery fires:

Additional information on lithium-type battery fires may be found by clicking on this link: SAFO 09013SUP.pdf.

The FAA has developed a training video to demonstrate effective techniques for fighting lithium-type battery fires. See the Video on Laptop Battery Fires at http://www.fire.tc.faa.gov/2007Conference/proceedings.asp Click on the "Training Videos" link on the lower right of the page.

Recommended Action: Directors of safety, directors of operations, training managers, and crewmembers should collaborate to include these procedures in the operator's manuals, operations, and training.

Approved by: AFS-200 OPR: AFS-220

Battery Types

- **Three battery manufacturers have submitted cells for testing**

	Battery Cell #1	Battery Cell #2	Battery Cell #3
Battery Type	Cylindrical Li-ion	Cylindrical Li-ion	Li-Polymer
Battery Size	18650*	26650*	3 ½″ x 4″ x ¼″
Chemistry	Lithium Iron Phosphate	Lithiated Metal Phosphate	Lithium Cobalt Dioxide
Capacity (mAh)	1150	2300	8000

**** 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

	Trial 1		Trial 2	
	Ignition Temp (F)	Peak Temp (F)	Ignition Temp (F)	Peak Temp (F)
Cell Type #1	440	572	490	649
Cell Type #2	480	664	527	639
Cell Type #3	340	741	330	788

Lithium-Ion Batteries

Bulk Load Configuration before Testing

Lithium-Ion Batteries

Bulk Load Configuration after Testing

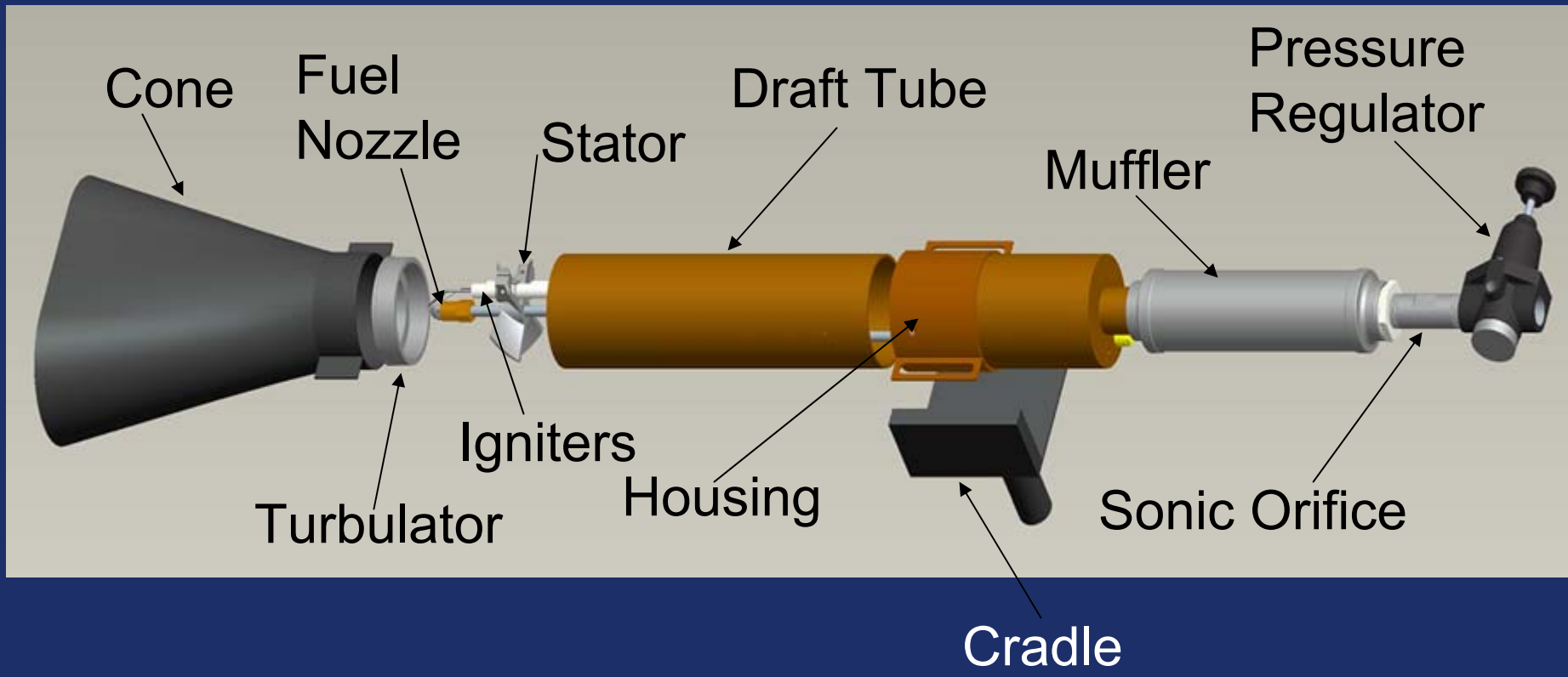
Post Crash Burn-through Protection

- **Development of guidance material and support for transport airplane burn-through requirement (Effective 9/2/09).**
- **Drivers:**
  - Impending complex insulation burnthrough resistence rule
  - Unavailability of Park Burner referenced in rule

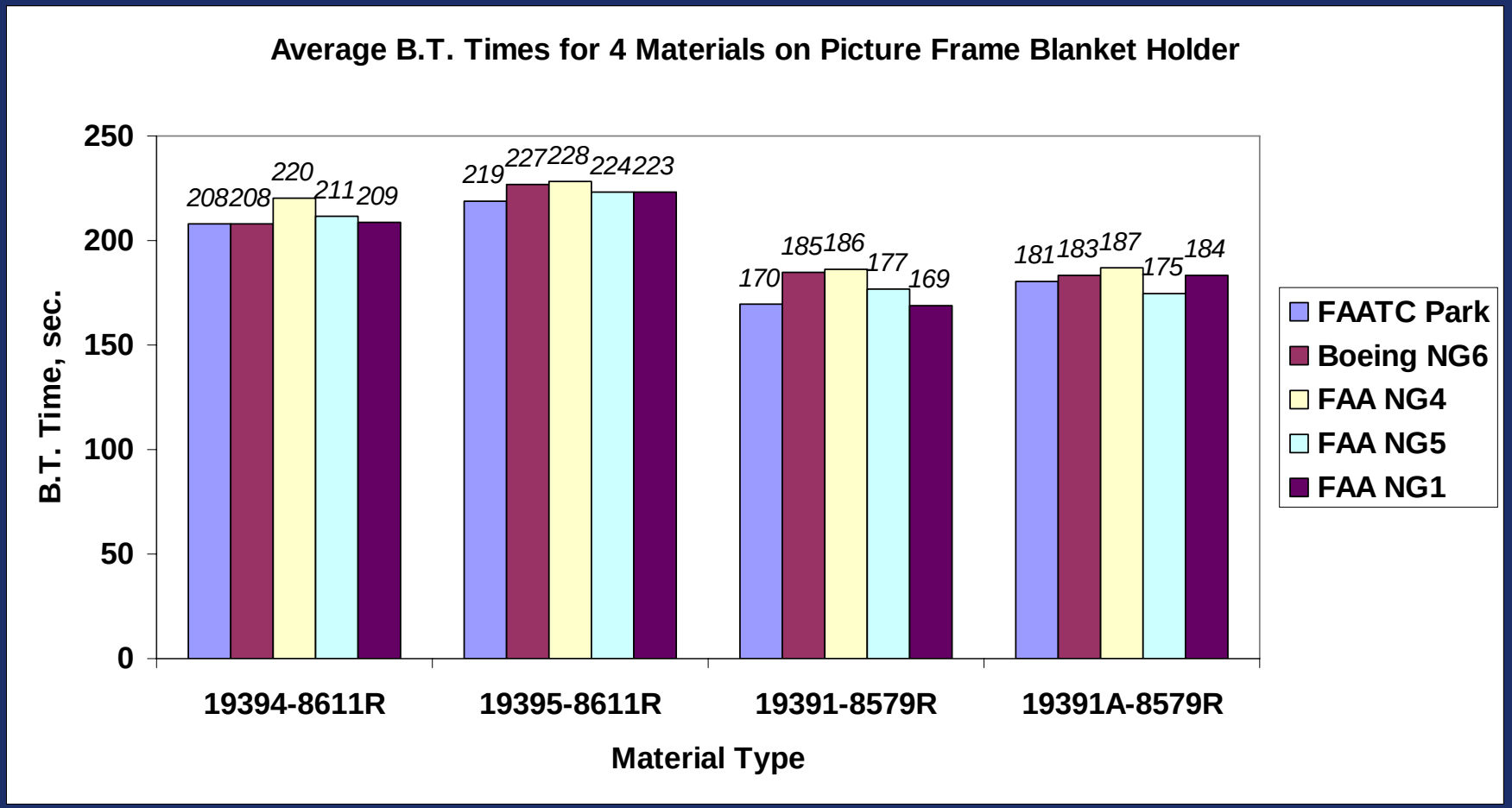
Post Crash Burn-through Protection

- **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



Full-Scale Test Results, Structural Composite System *During Test*

Full-Scale Test Results, Structural Composite System *Post-Test*

Fire Safety of New Material Technology

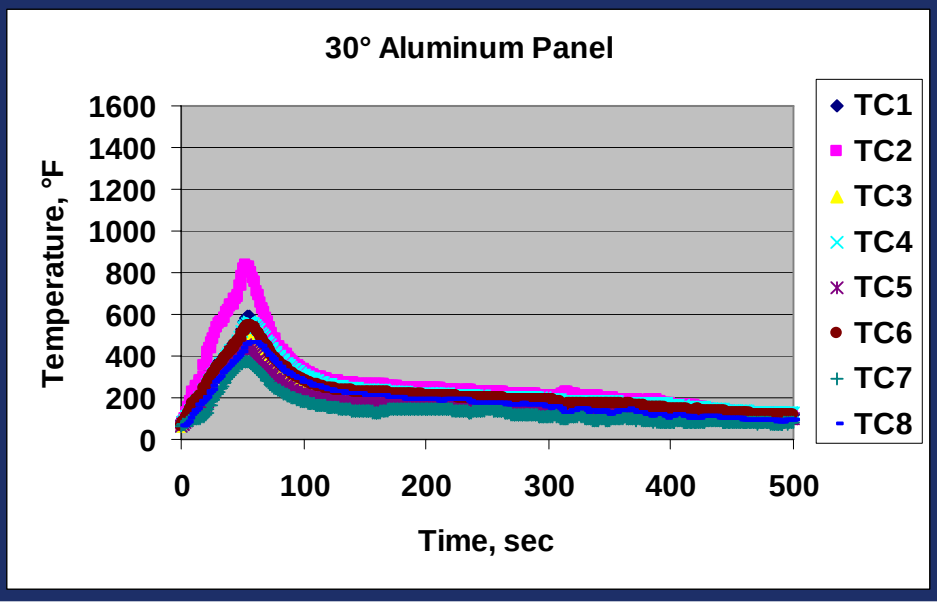
- **Determine the adequacy of present regulations and advisory material as it applies to new technology materials in aircraft (e.g., composite fuselage and wings)**
- **Where necessary, develop new test protocols and/or guidance materials.**
- **Drivers:**
  - New test methods would obviate the need for Special Conditions in new composite aircraft
  - New lightweight magnesium alloys are fire resistant

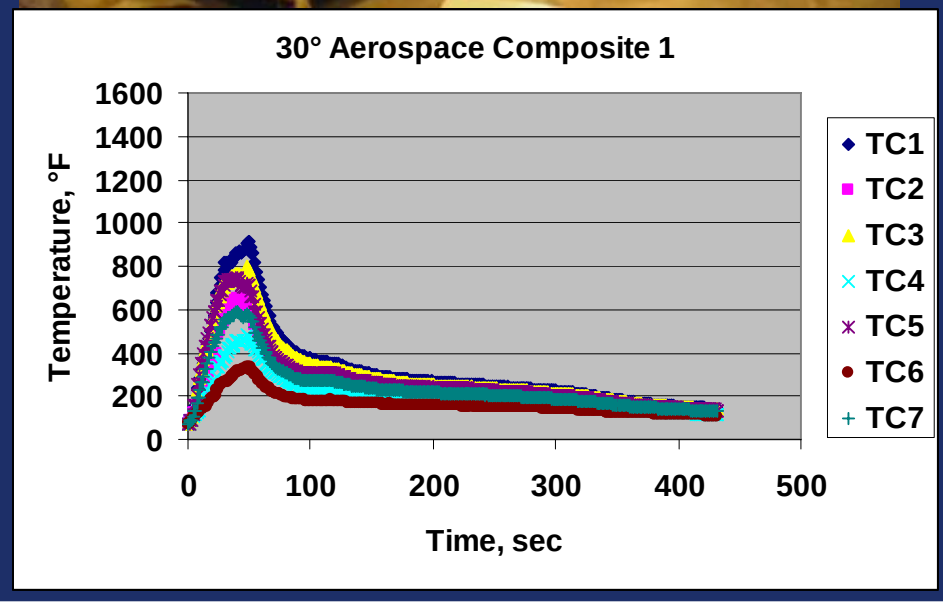
Fire Safety of New Material Technology

- **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

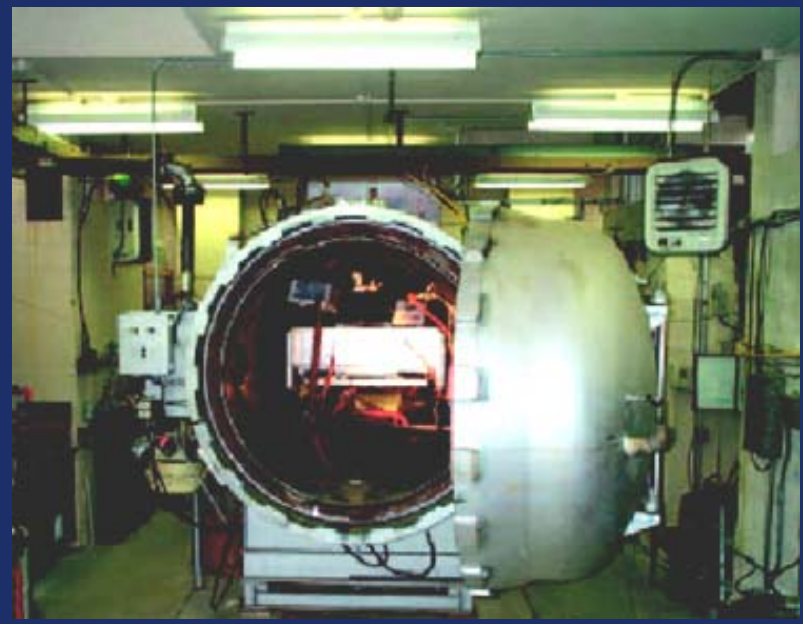
AZ-31 Test Results


30° Aluminum Panel
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8


30° Aerospace Composite 1
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7

Freighter Fire Safety

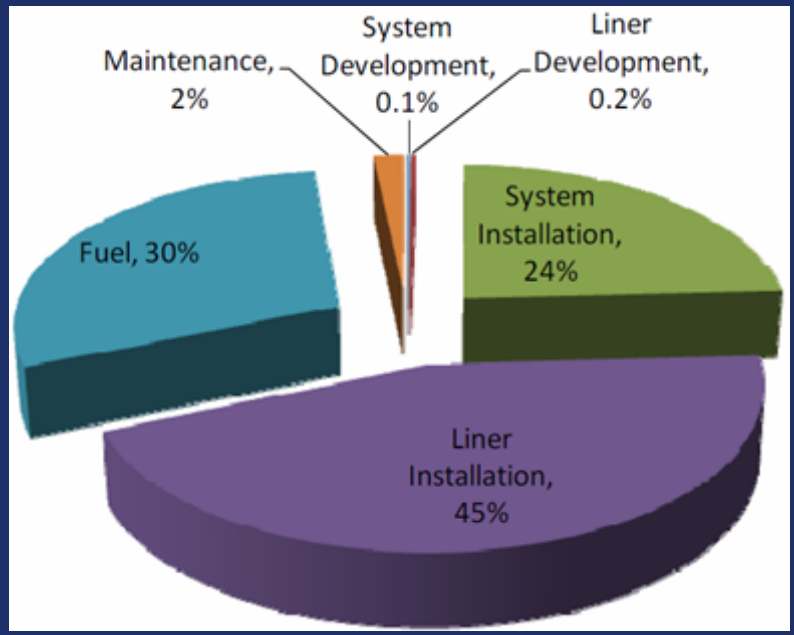
- **Determine the adequacy of current fire safety requirements in freighter aircraft and the feasibility and cost/benefit of fire detection and suppression improvements.**
- **Drivers:**
  - Freighter hull losses and serious incidents caused by fire
  - NTSB recommendations related to (1) adequacy of current detection means and (2) need for an on-board fire suppression system



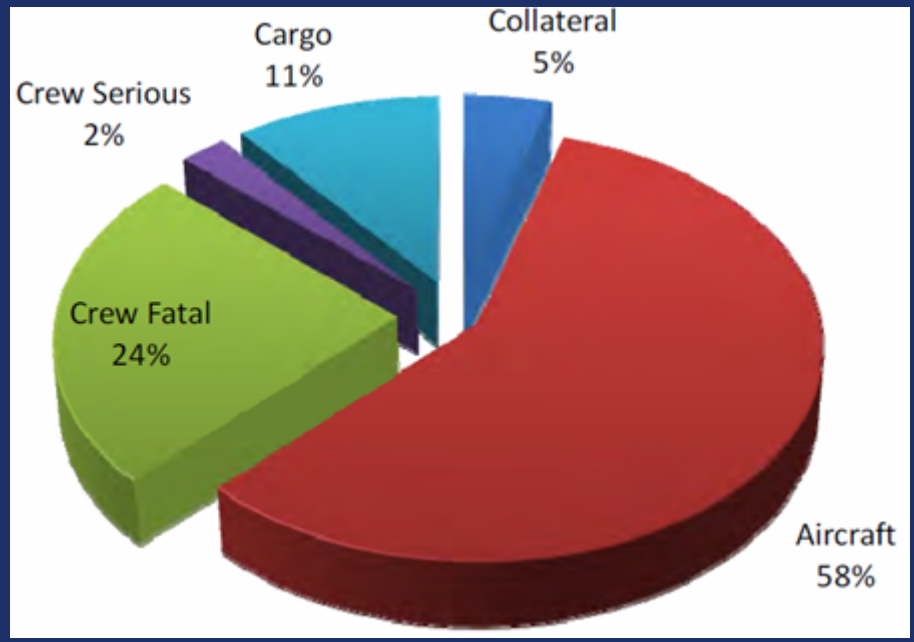
Freighter Fire Safety

- **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).

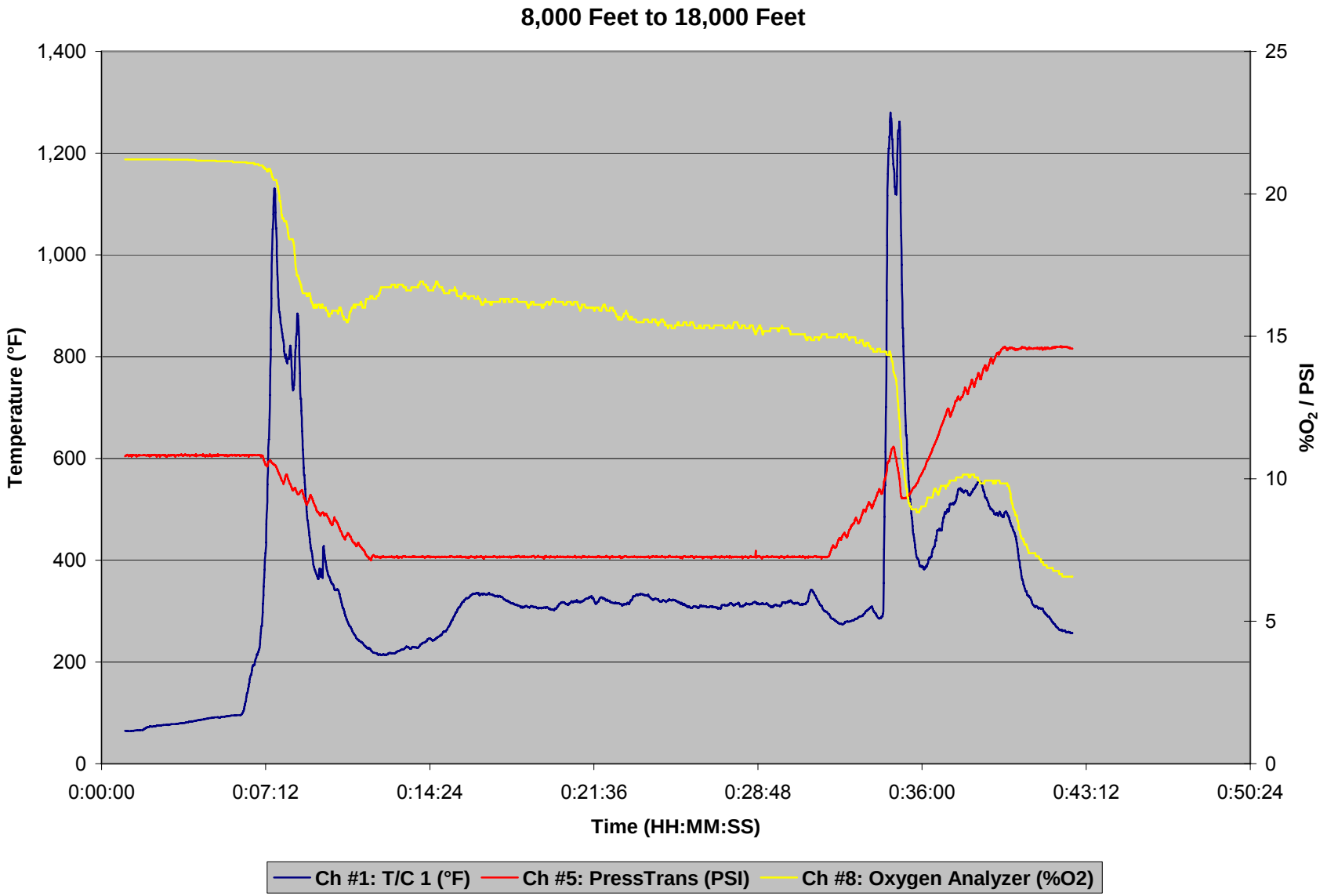
Freighter Fire Safety



Cost

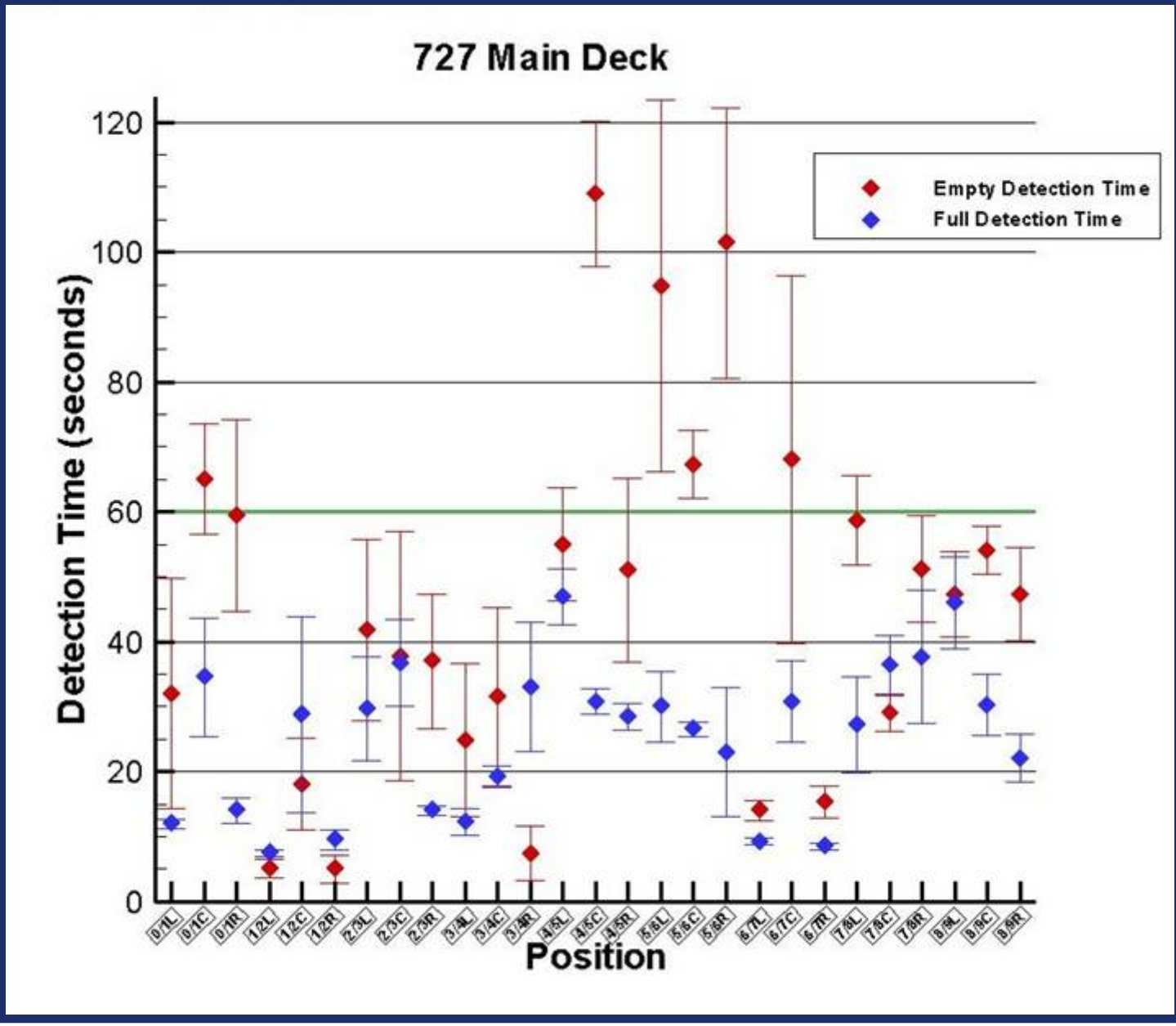


Benefit


8,000 Feet to 18,000 Feet
1,400
1,200
1,000
800
600
400
200
0
Temperature (°F)
25
20
15
10
5
0
%O2 / PSI
0:00:00
0:07:12
0:14:24
0:21:36
0:28:48
0:36:00
0:43:12
0:50:24
Time (HH:MM:SS)
Ch #1: T/C 1 (°F)
Ch #5: PressTrans (PSI)
Ch #8: Oxygen Analyzer (%O2)

727 Freighter

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)
120
100
80
60
40
20
0
Empty Detection Time
Full Detection Time
0/1L
0/1C
0/1R
1/2L
1/2C
1/2R
2/3L
2/3C
2/3R
3/4L
3/4C
3/4R
4/5L
4/5C
4/5R
5/6L
5/6C
5/6R
6/7L
6/7C
6/7R
7/8L
7/8C
7/8R
8/9L
8/9C
8/9R
Position

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

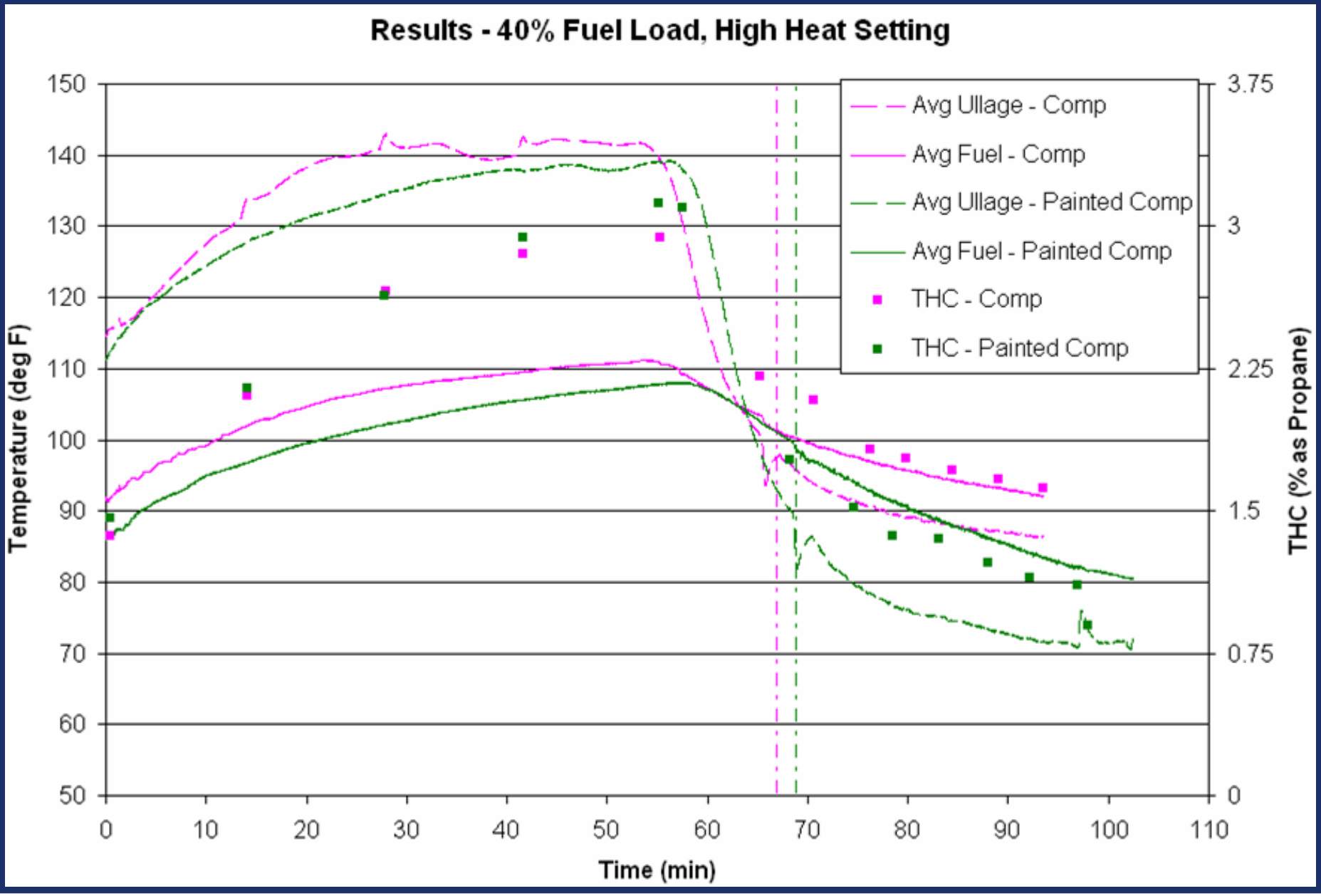
Fuel Tank Flammability/Protection

- **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**


Results - 40% Fuel Load, High Heat Setting
Temperature (deg F)
THC (% as Propane)
Time (min)
Avg Ullage - Comp
Avg Fuel - Comp
Avg Ullage - Painted Comp
Avg Fuel - Painted Comp
THC - Comp
THC - Painted Comp
150
140
130
120
110
100
90
80
70
60
50
3.75
3
2.25
1.5
0.75
0
0
10
20
30
40
50
60
70
80
90
100
110

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)
- AN-26 Insulation Airworthiness Directive (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 Protection Containers for Oxygen Cylinders and Generators Rule (2009)
- Fire Safe Transportation of Lithium Batteries (Pending)