Evolution of FAA Fire Safety R&D Over the Years

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The Fifth Triennial Fire & Cabin Safety Research Conference

Tropicana Casino Resort
Atlantic City, NJ
October 29 – November 1, 2007

1940's and 1950's

- Piston Engine Powerplant Fires Greatest Concern
- Simulated Flight Piston Engine Fire Tests
- Powerplant Component Fire Tests
- Extinguishing Systems
- Fire Detectors
- Lightning/Fuel Vent Systems
- Simulated Flight Turbine-Engine Fire Tests

1960's

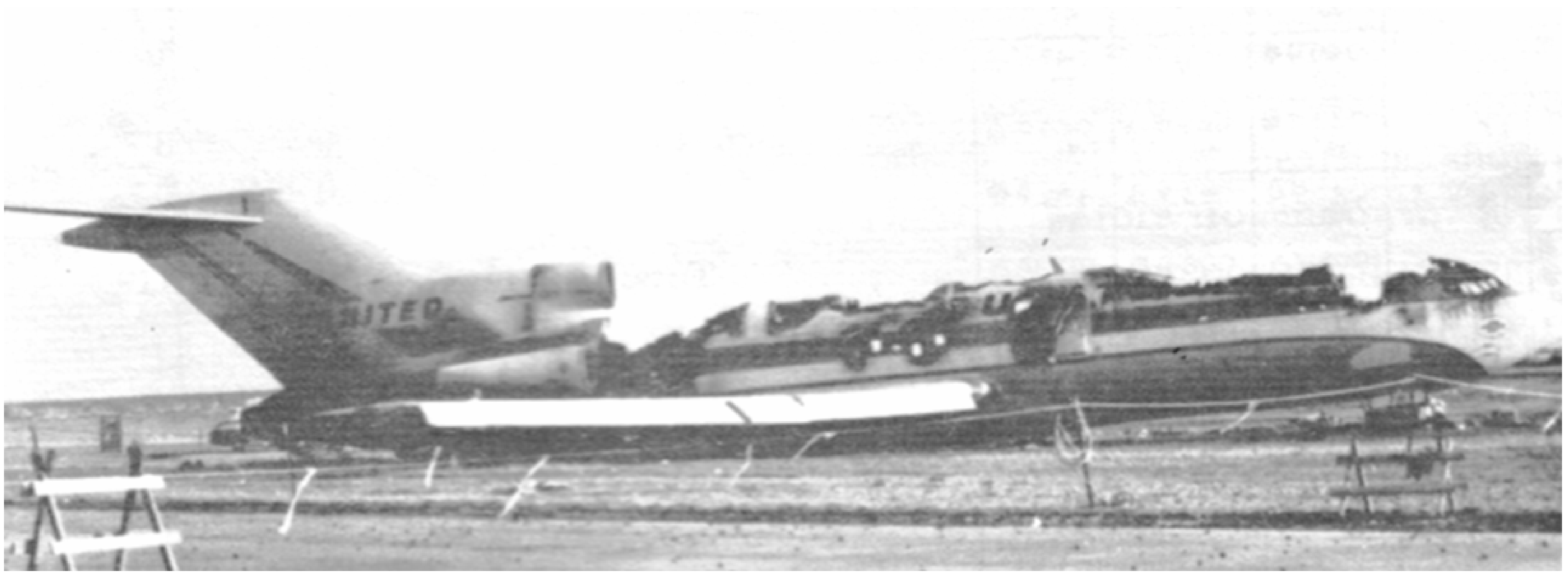
Accident Drivers

- DC8, Denver, 7/61
- 707, Rome, 11/64
- 727, Salt Lake City, 11/65
- Viscount, Parrotsville, 7/64

R&D

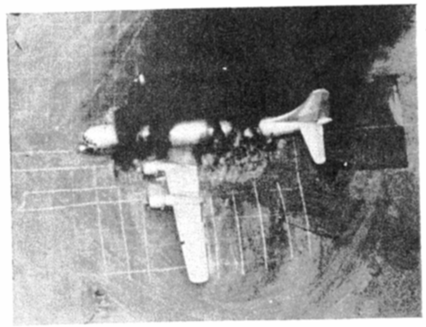
- First Cabin Material Flammability Tests (Vertical Bunsen Burner, ASTM-162)
- Development of NBS Smoke Chamber
- Unusual Fire Hazards of Urethane Foam Cushions
- Full-Scale Postcrash Fire Survivability and Fire Fighting Tests
- Gelled Fuel

Salt Lake City Accident

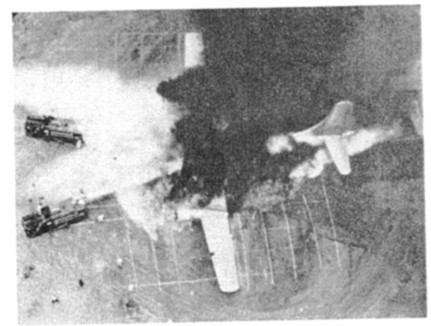


In-Situ Cabin Fire Tests in DC7 Fuselage (ca. 1964)

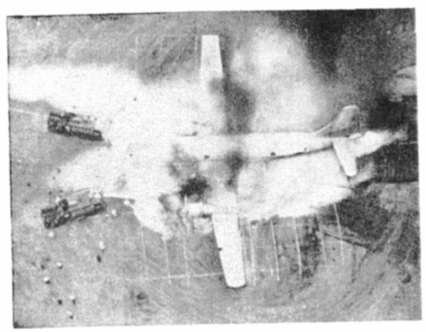
Post-Crash Fire-Fighting Studies on Transport Category Aircraft (ca 1965)



t = 58 SEC.



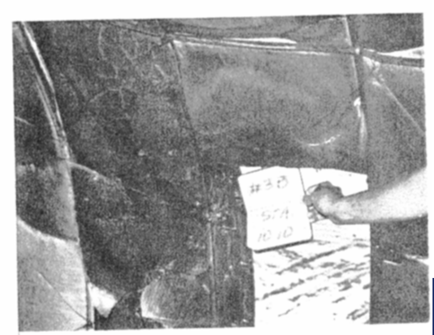
t = 150 SEC.



t = 200 SEC.

t = 565 SEC.

POST BURN SCENE



INTERIOR SCENE
STA. 1010

1970's

Accident Drivers

- DC8, Anchorage, 11/70
- 737, Chicago, 12/72
- DC9, Chicago, 12/72
- 707, Paris, 7/73
- 747/747, Tenerife, 3/77
- DC10, Los Angeles, 3/78

R&D

- **Toxicity of Burning Materials**
  - Gas Analysis (NAFEC)
  - Rodent Exposure (CAMI)
- **Combined Hazard Index Concept**
- **Full-Scale Test Effectiveness of Halon 1301 and Compartmentation in a Postcrash Fire**
- **Full-Scale/Modeling Postcrash Fire Cabin Hazard Characterization Tests**
- **Fuel Tank Inerting (Cryogenic Nitrogen)**
- **Evacuation Slide Heat Resistance**
- **Anti-Misting Kerosene**

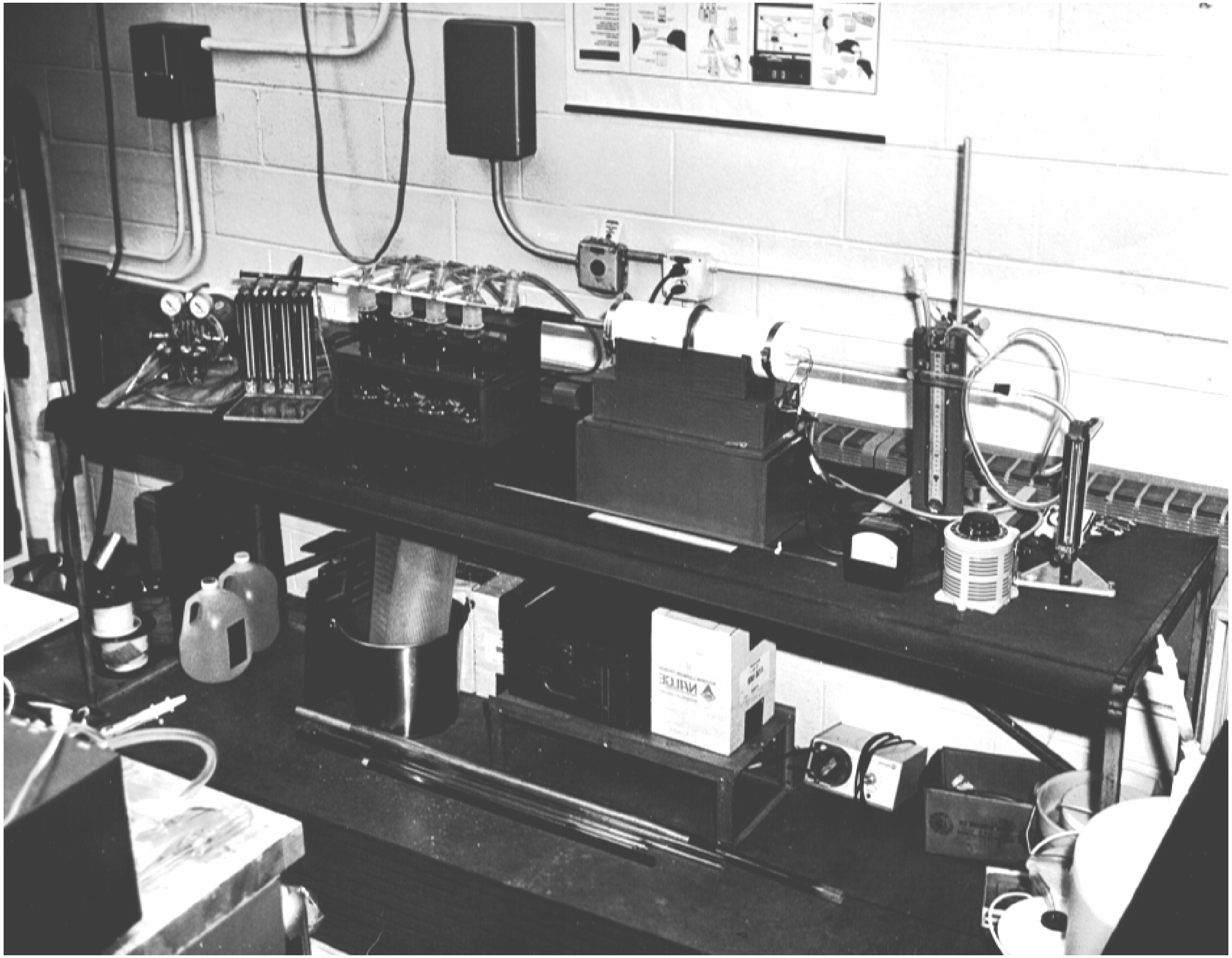
Varig 707

Paris, France; July 11, 1973

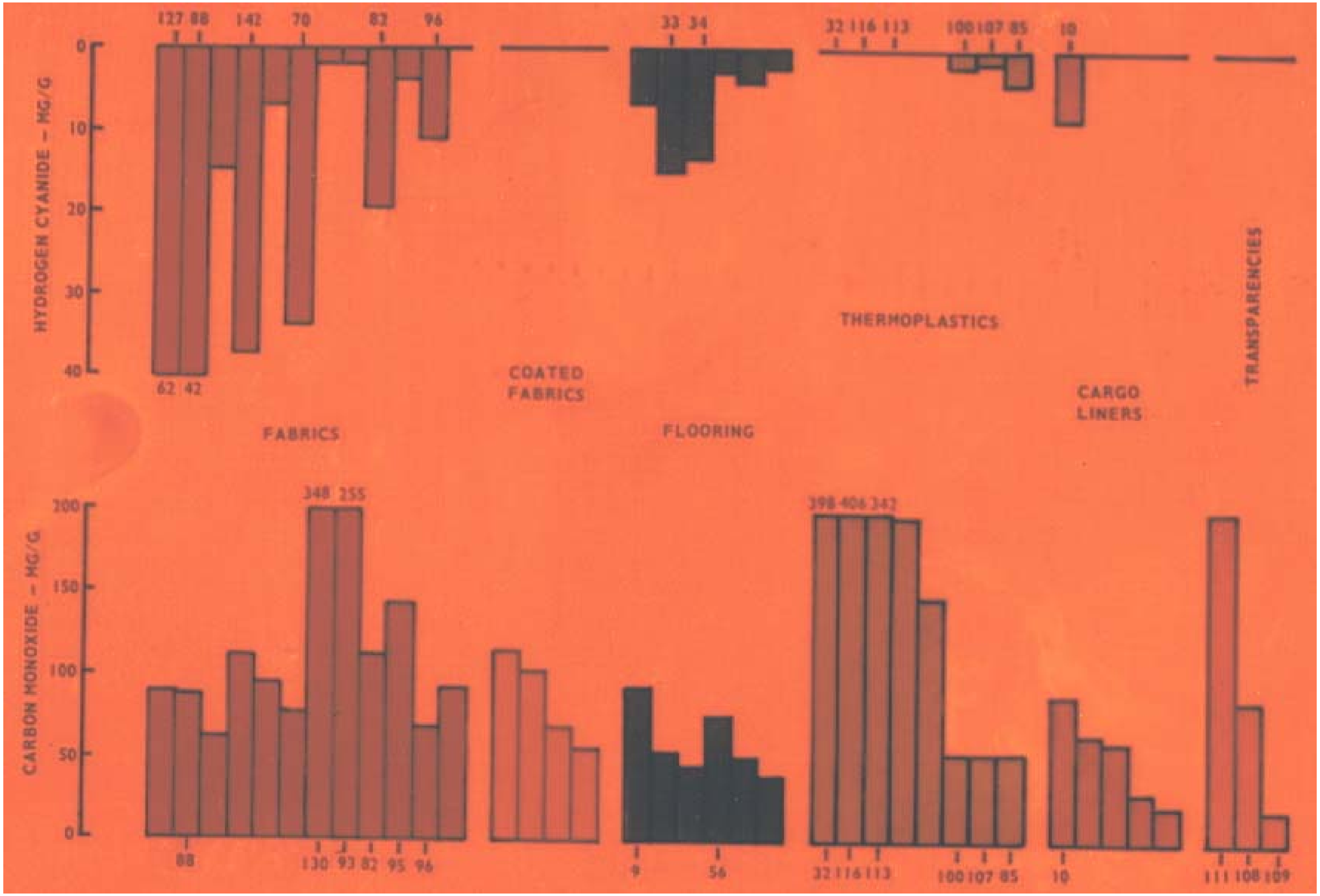
Continental DC-10

Los Angeles, California; March 1, 1978

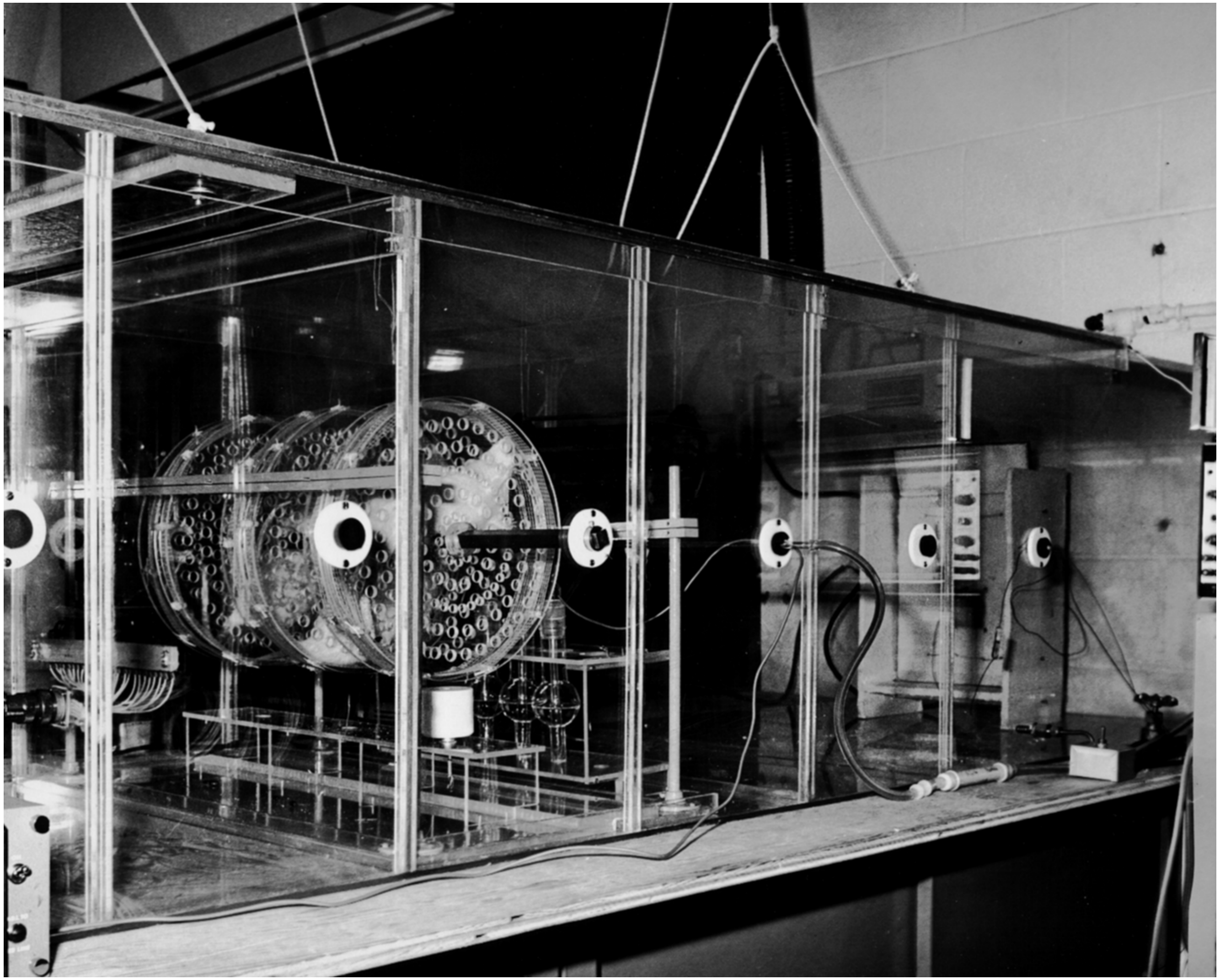
NAFEC Combustion Tube Furnace



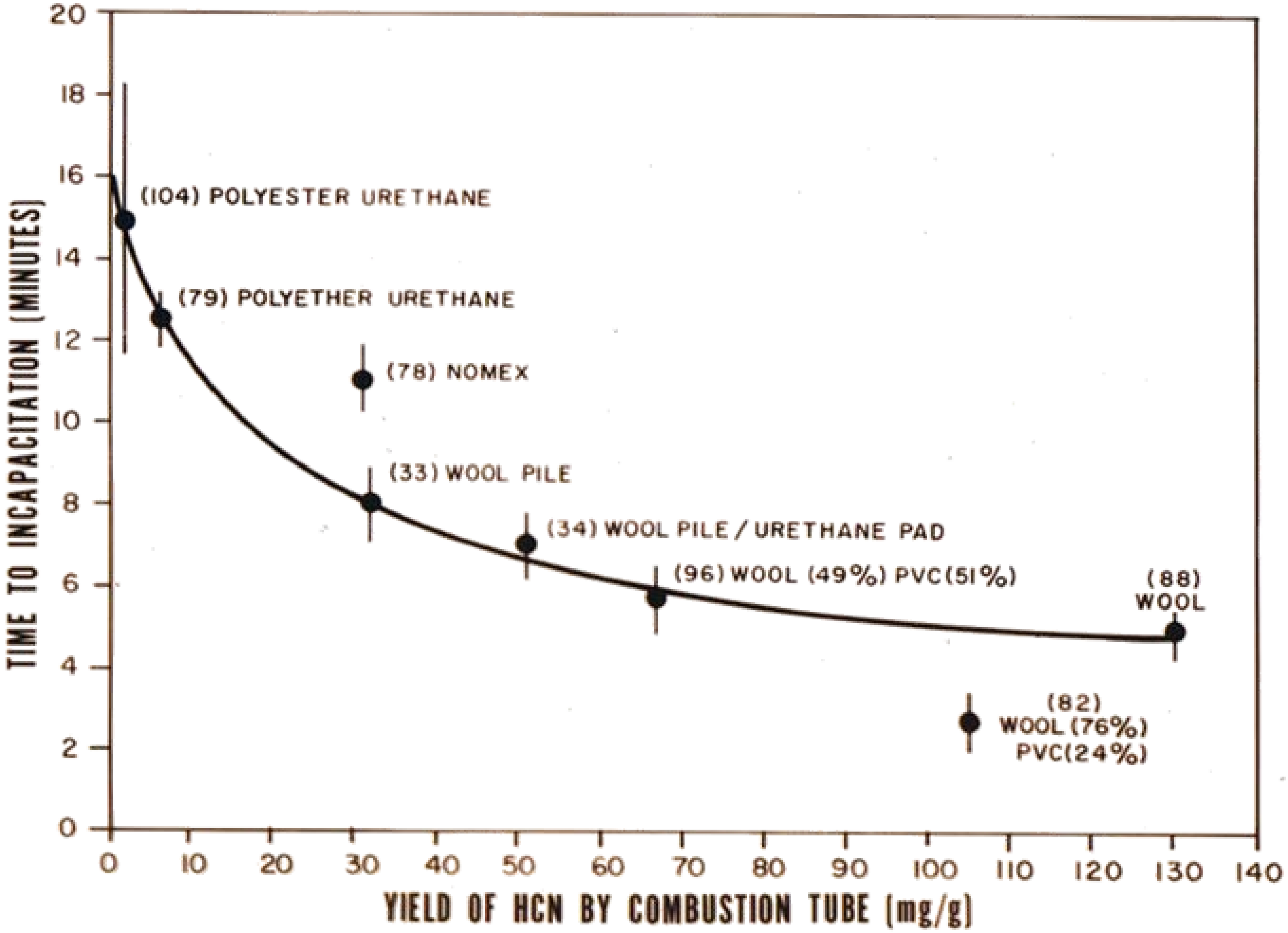
Toxic Gas Emission Characteristics



CAMI Rotating Wheel



Correlation of Animal Response with Yield of HCN Measured by the Combustion Tube

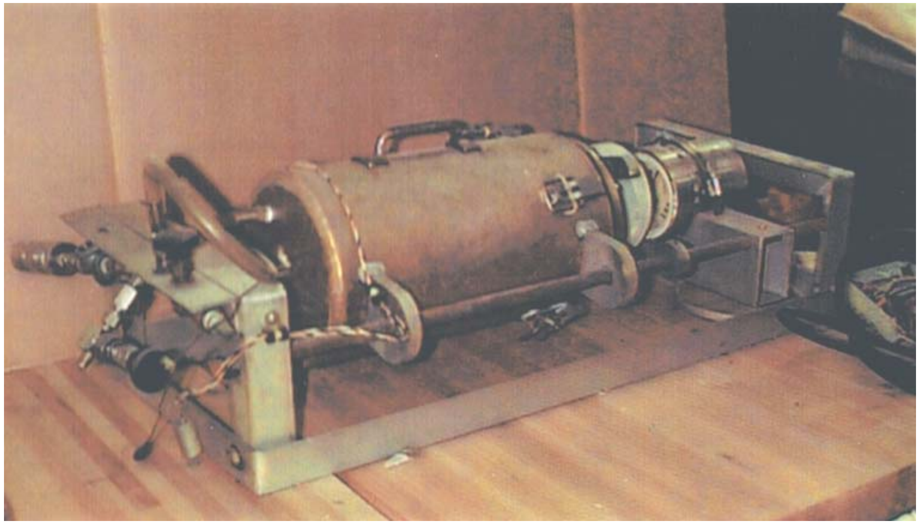


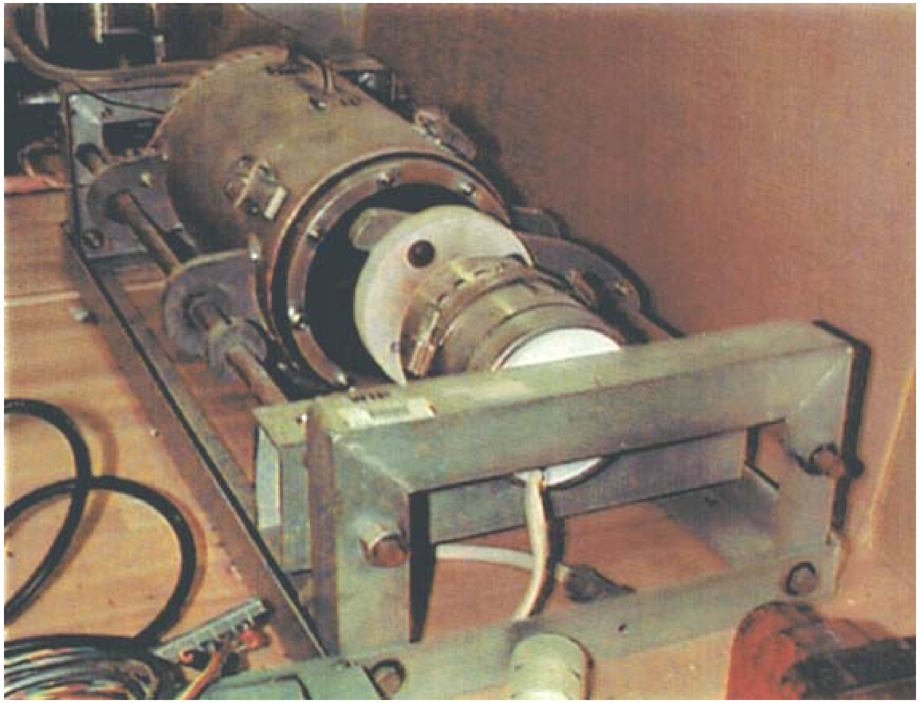
Physical Modeling of Postcrash Fuel Fire, Fuselage Door Opening and Wind Effects

Full-Scale Anti-Misting Kerosene Catapult Test

Full-Scale Test Exposure of Evacuation Slides to a Postcrash Fuel Fire

Radiant Heat Testing of Evacuation Slides, Ramps and Rafts





1980's

Accident Drivers

- L-1011, Riyadh, 8/80
- DC9, Cincinnati, 6/83
- 747 Combi, Indian Ocean, 11/87
- 737, Manchester, 8/85
- 727, Dallas, 8/88
- DC10, Malaga, 9/82
- 747, Seoul, 11/80

R&D

- Seat Cushion Fire Blocking Layers
- Heat Release Rate (OSU) Test Method for Large Surface Area Cabin Materials
- Electrical Wiring Arc Tracking
- Cargo Liner Burnthrough Resistance
- Aircraft Material Fire Test Handbook
- Seat Gasoline Fire Extinguishment (Halon 1211 Hand-Held Extinguisher)
- Floor Proximity Lighting
- Passenger Smoke Hoods (Reexamined)
- Cabin Water Spray
- In-Flight Smoke Venting

Note: Full-Scale Fire Test Facility became Operational in 1980

Saudia L-1011

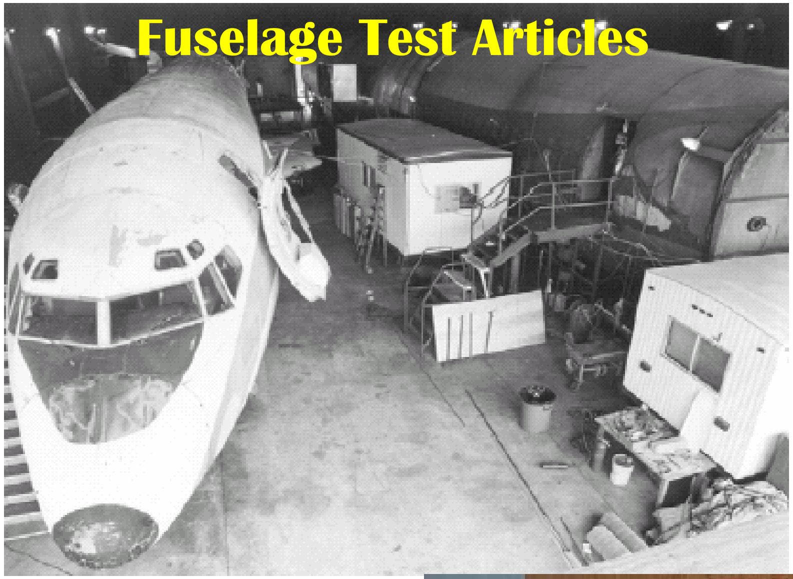
Riyadh, Saudi Arabia; August 19, 1980

Air Canada DC-9

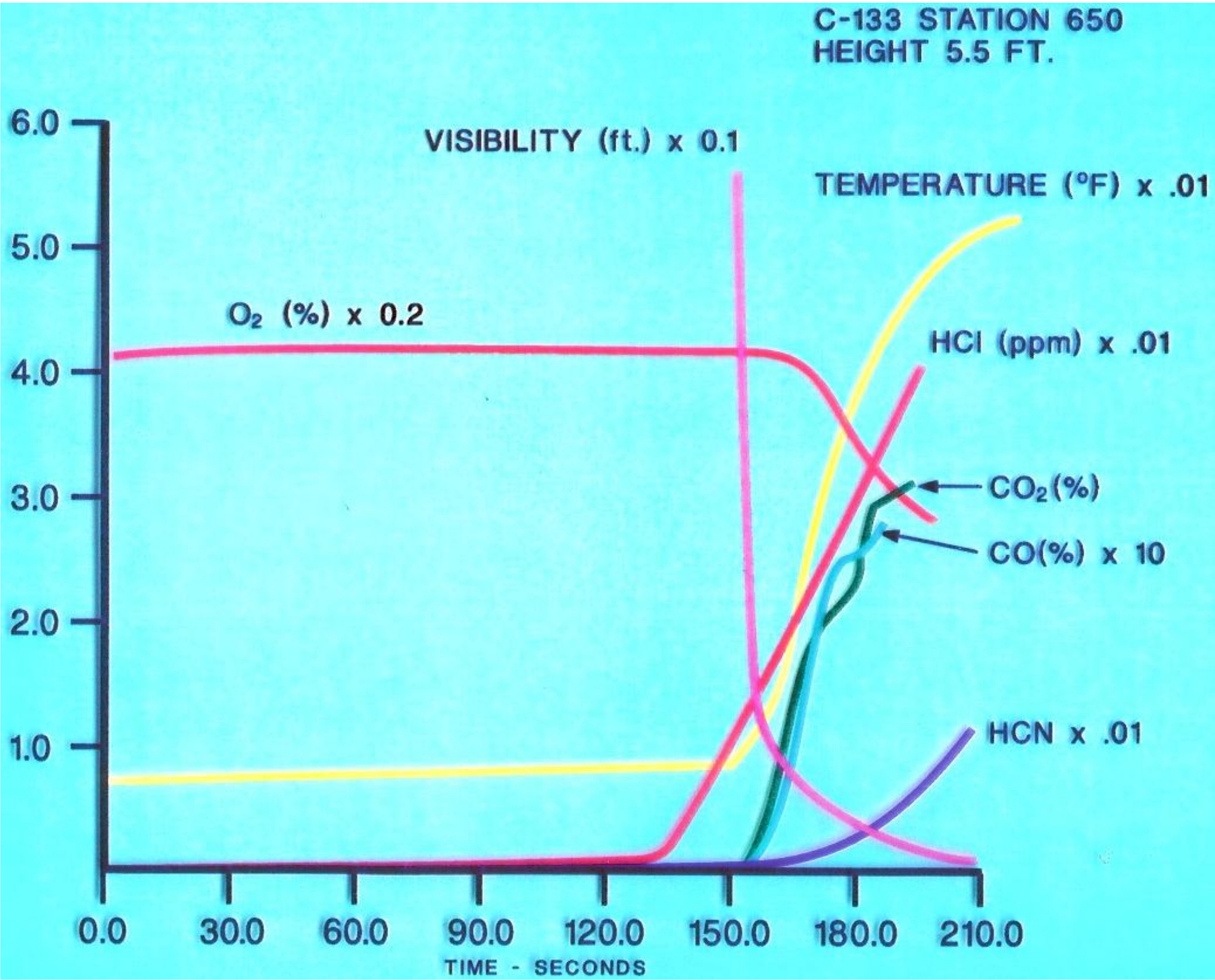
Cincinnati, Ohio; June 2, 1983

Manchester Accident

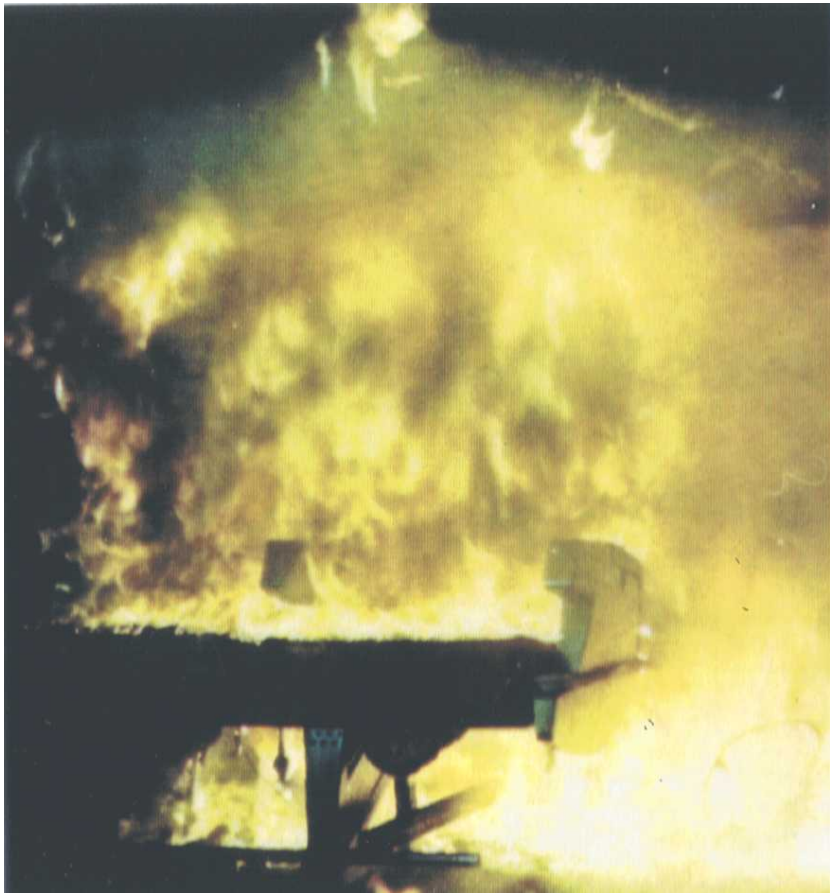
Full-Scale Fire Test Facility



Wide Body Cabin Hazard Histories (C-133)



Effectiveness of Fire-Blocked Seats During Full-Scale Fire Tests

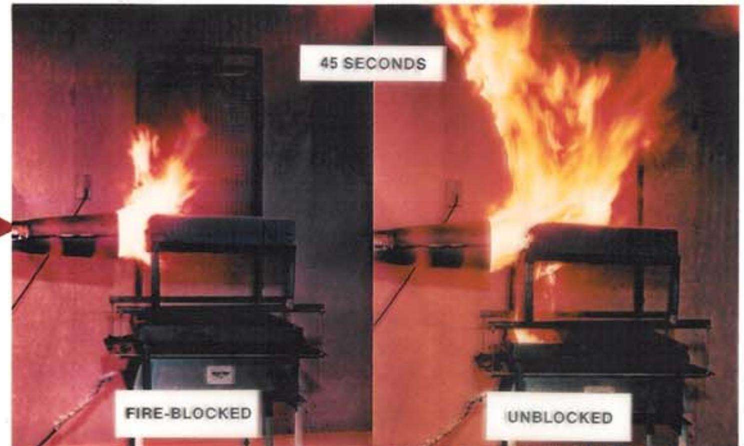


Unblocked @ 120 Seconds

Blocked @ 120 Seconds

Seat Fire Blocking Layer Benefits

Fire Test Standard



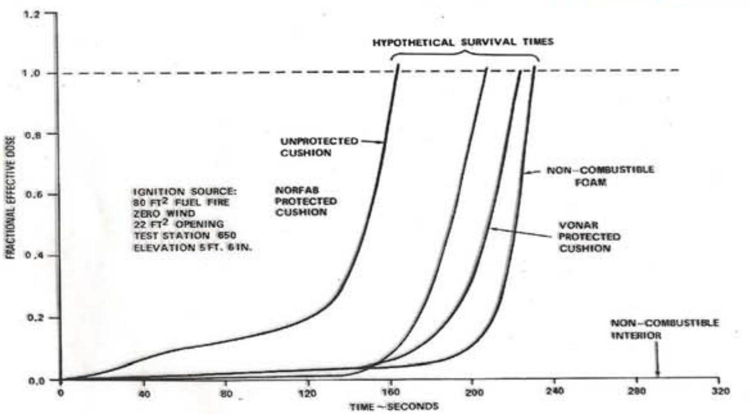
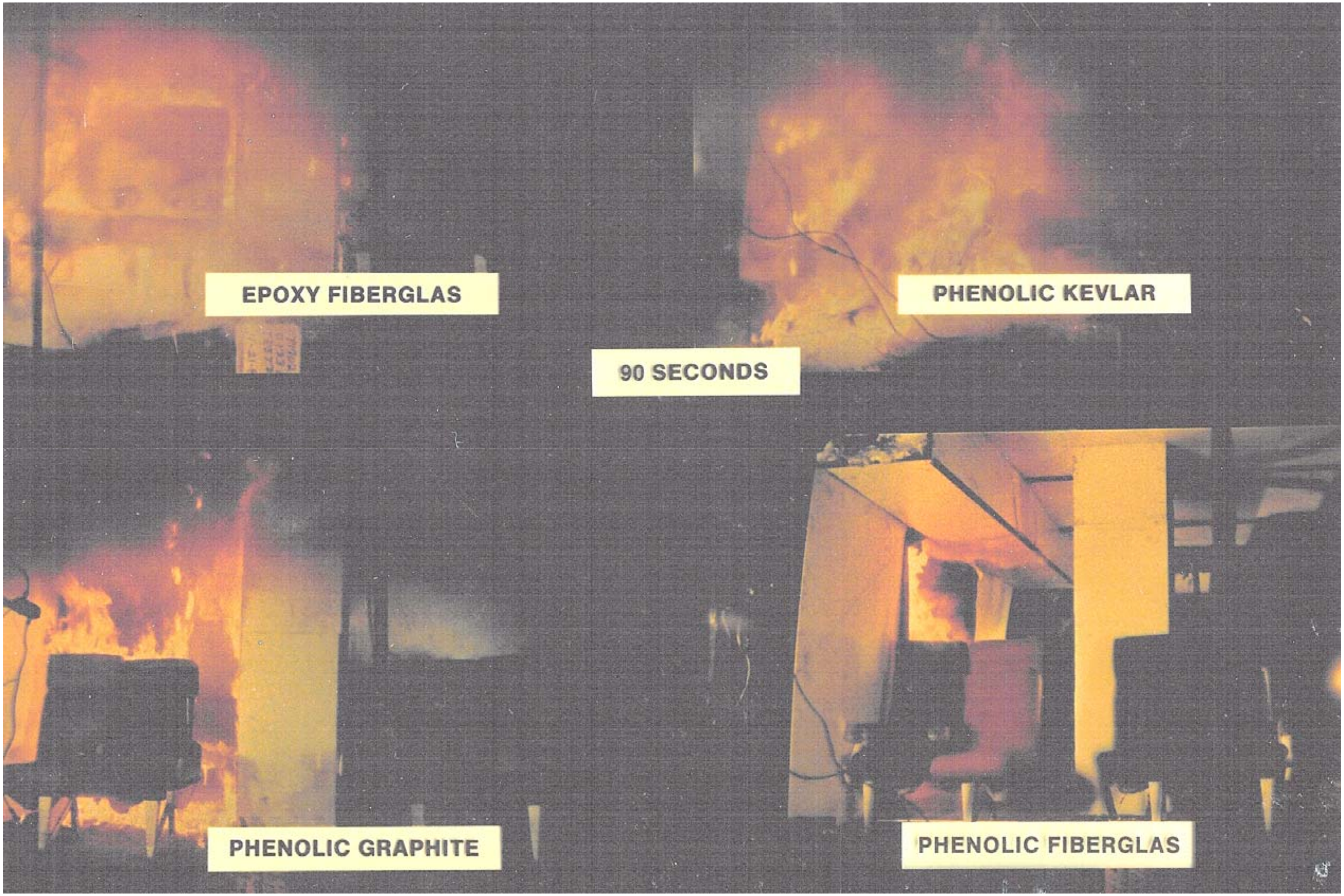


FIGURE 2. EFFECT OF SEAT CUSHION PROTECTION ON FRACTIONAL EFFECTIVE DOSE

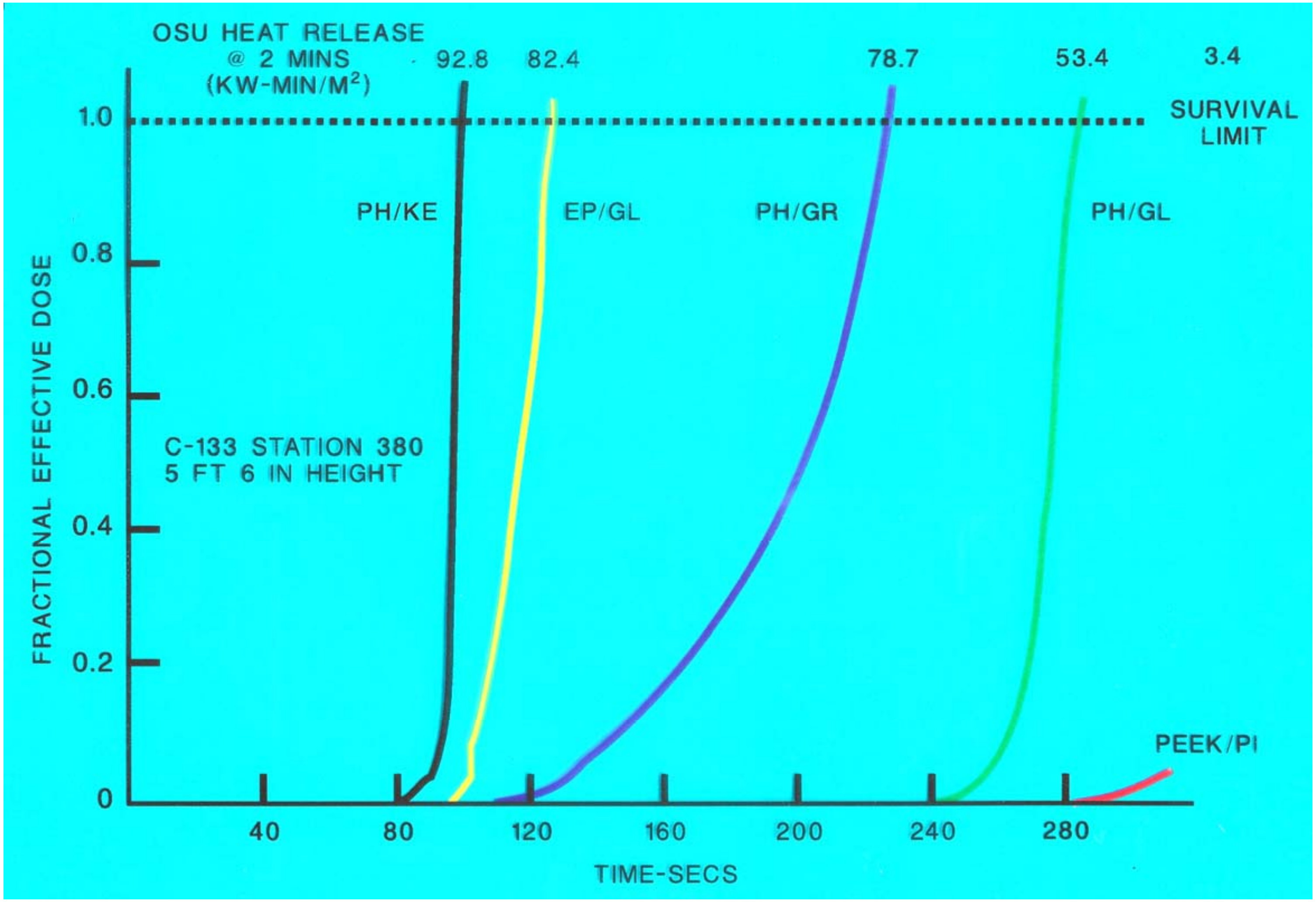
Full-Scale Test Benefit

Accident Benefit

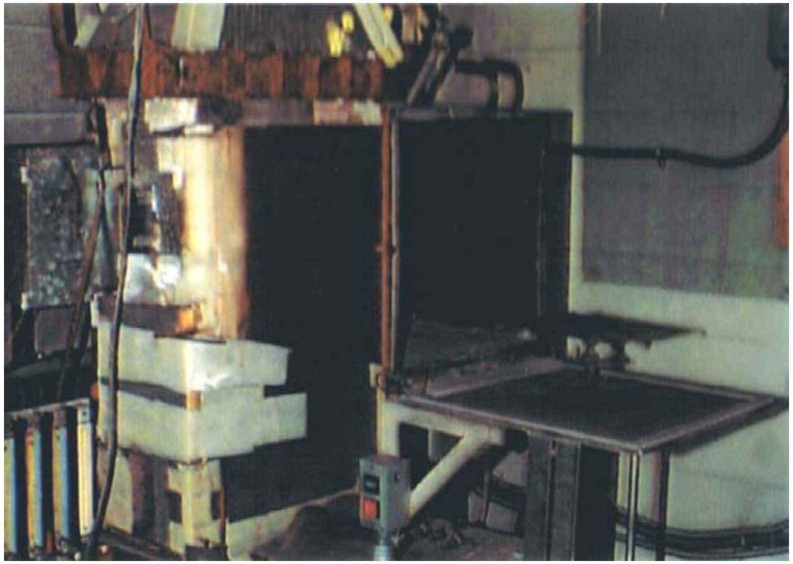
C-133 Correlation Test Results



Effect of Composite Panel Design on Fractional Effective Dose and OSU Heat Release

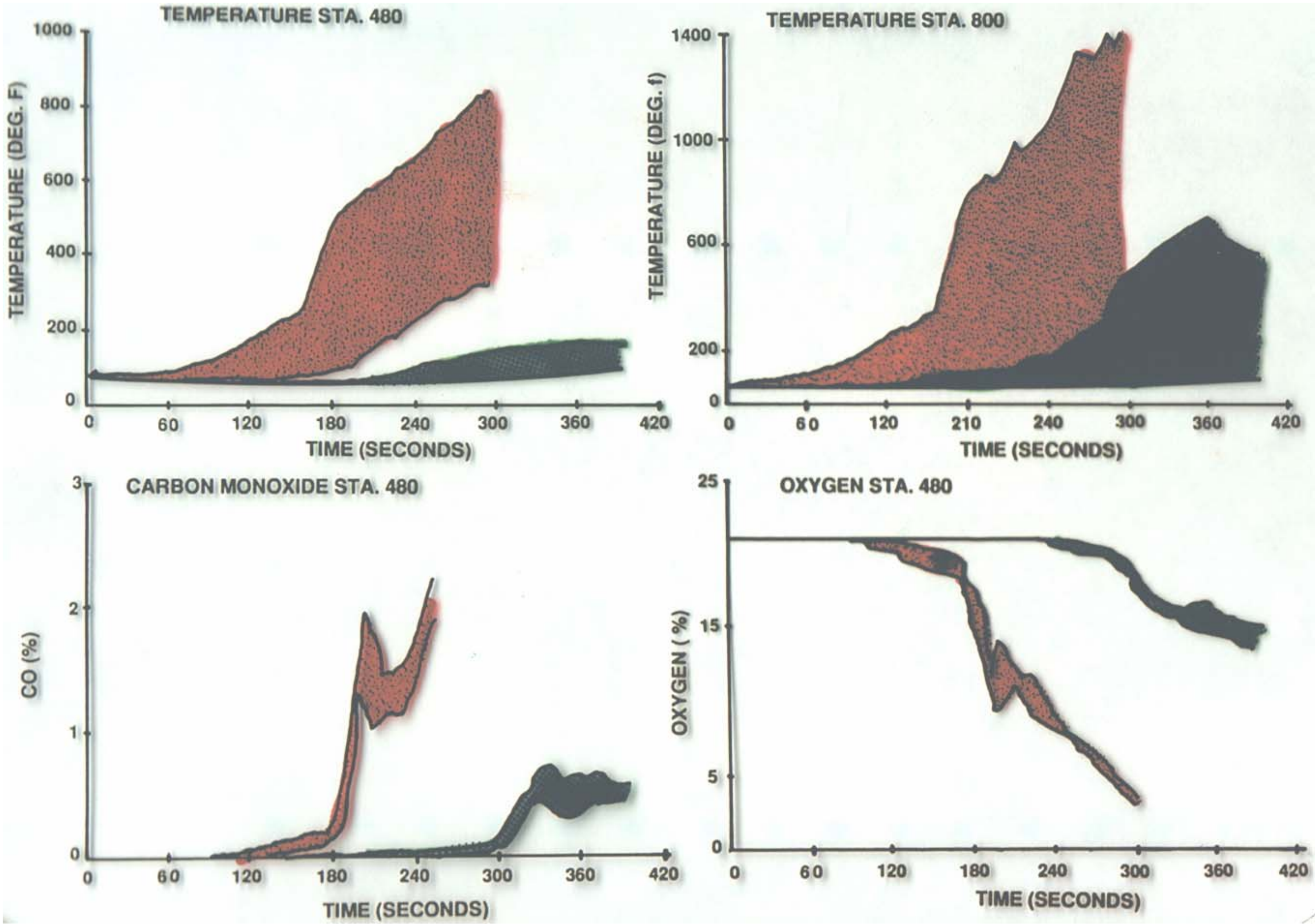


Heat Release Rate Test for Cabin Materials



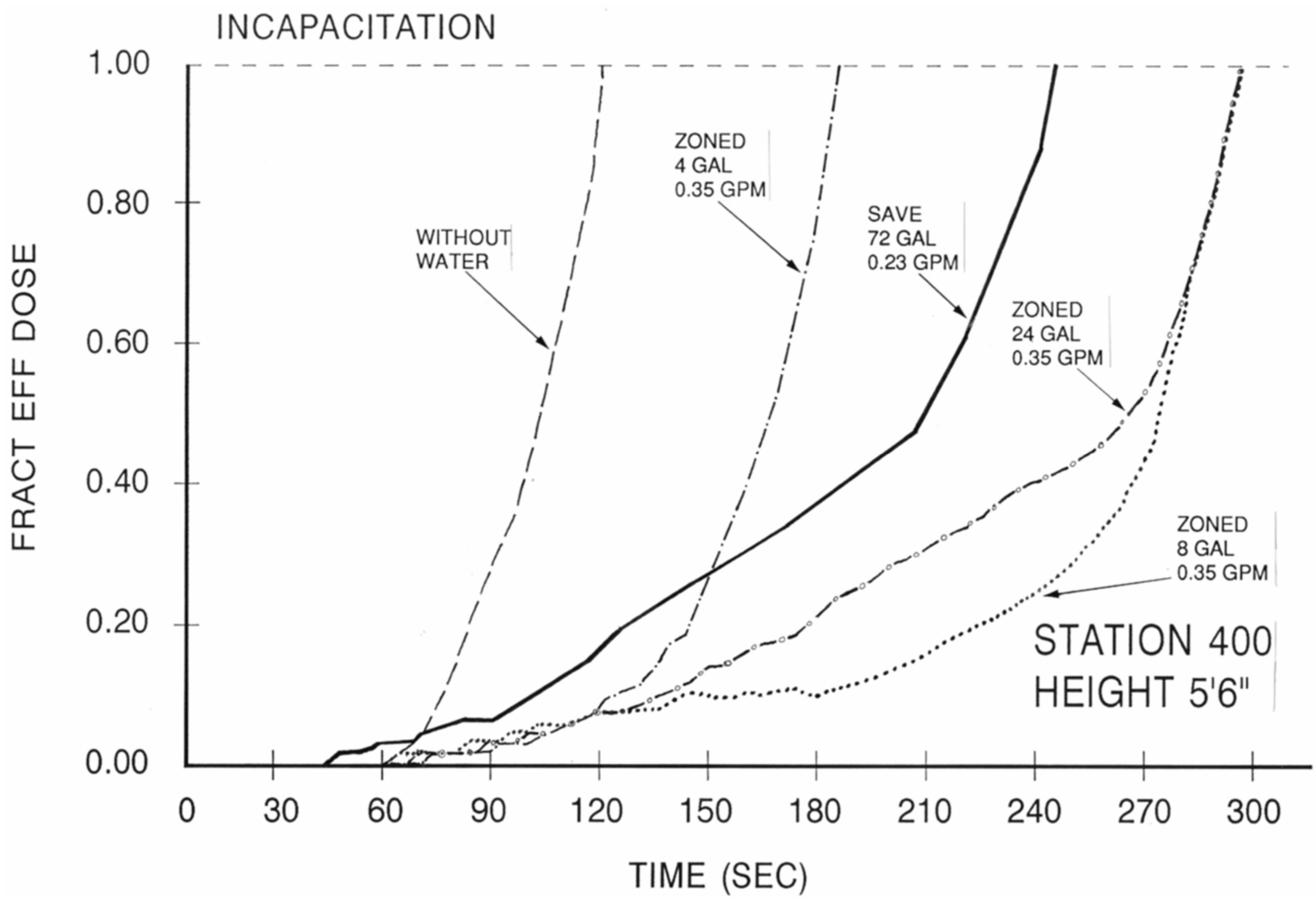
Cabin Water Spray Results (707)

External Fuel Fire/Fuselage Opening/Wind



Red = Standard & Green = Waterspray

Improved Survival Gained by Zoned Water Spray



1990's

Accident Drivers

- DC9, Everglades, 5/96
- 747, New York, 7/96
- MD11, Nova Scotia, 9/98
- DC9, Detroit, 12/90
- 737, Los Angeles, 2/91
- 737, Manilla, 5/90

R&D

- Halon Replacement
- Exploding Aerosol Cans
- Fuel Tank Flammability
- Ground Based Inerting Cost Analysis
- Thermal Acoustic Insulation
  - Radiant Panel Test (In-Flight Fire Ignition Resistance)
  - Oil Burner Test (Postcrash Fire Burnthrough Resistance)
- Flight Data Recorders Fire Resistance
- Aircraft Command in Emergency Situations (ACES)
- Fire Research Program (Ultra-Fire Resistant Materials)

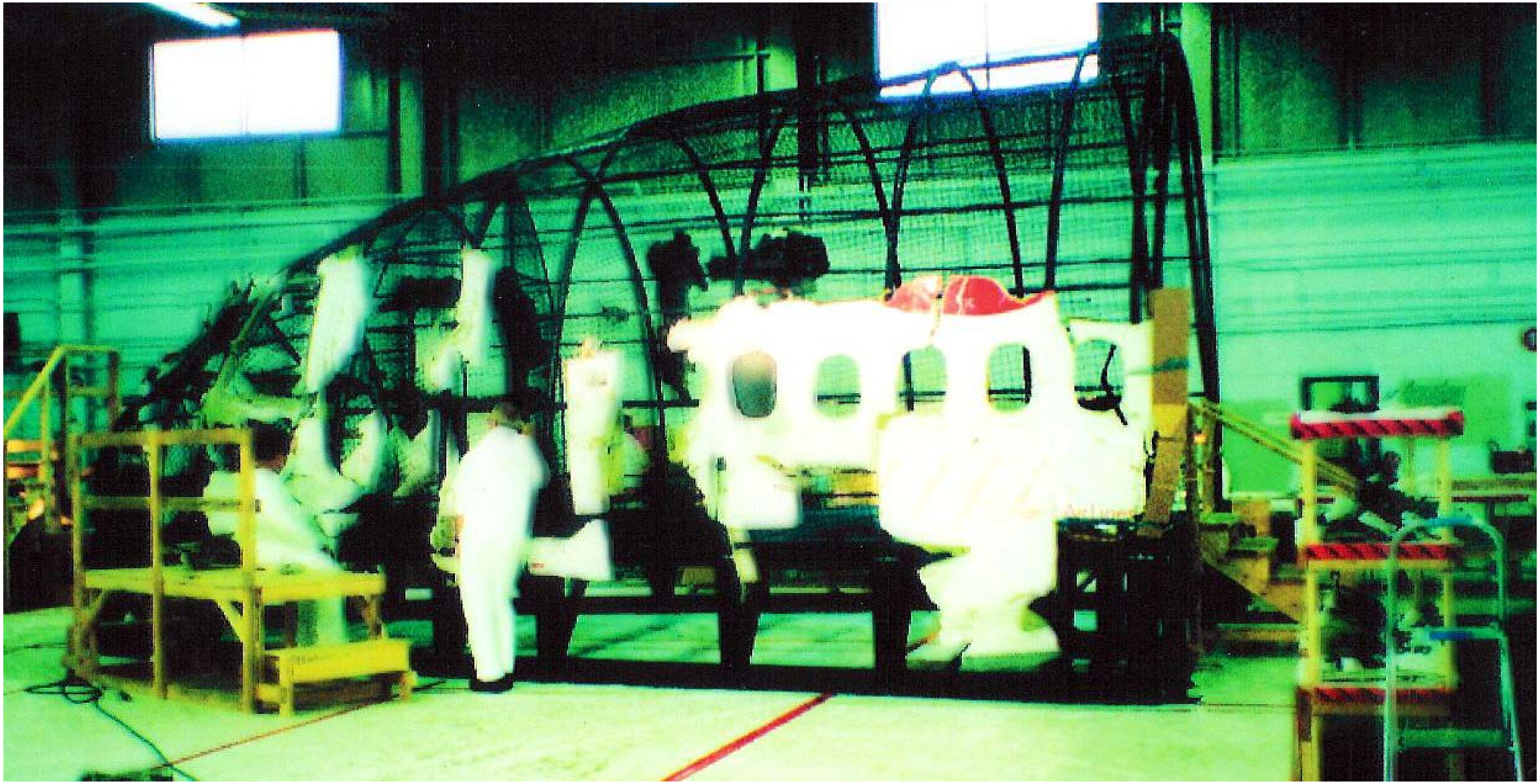

ValuJet DC-9
May 11, 1996
near Miami, FL

Trans World Airlines

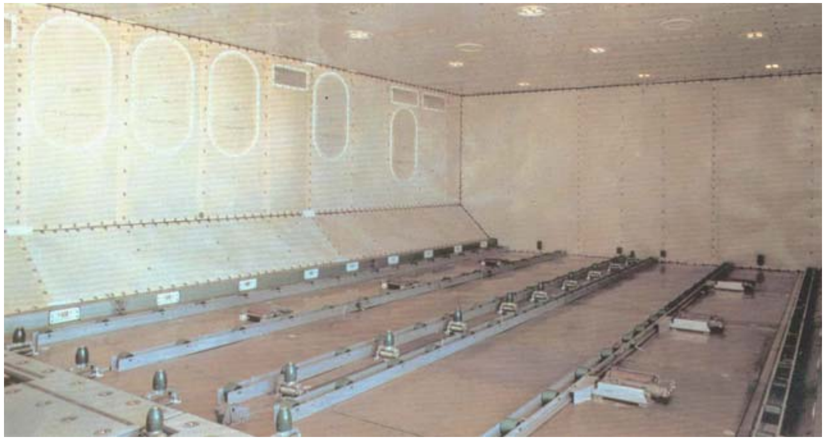
Boeing B747-131; July 17, 1996

Swiss Air MD-11

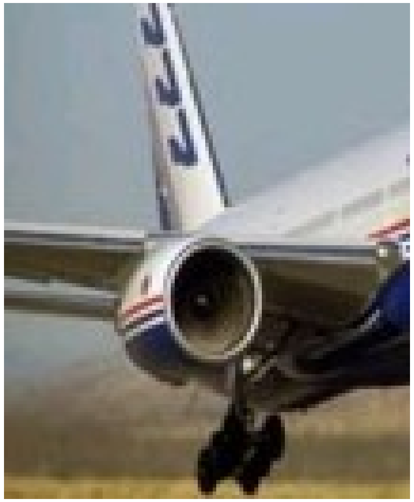
Peggy's Cove, Nova Scotia; September 2, 1998



Current Usage of Halon 1301/1211



Cargo Compartments

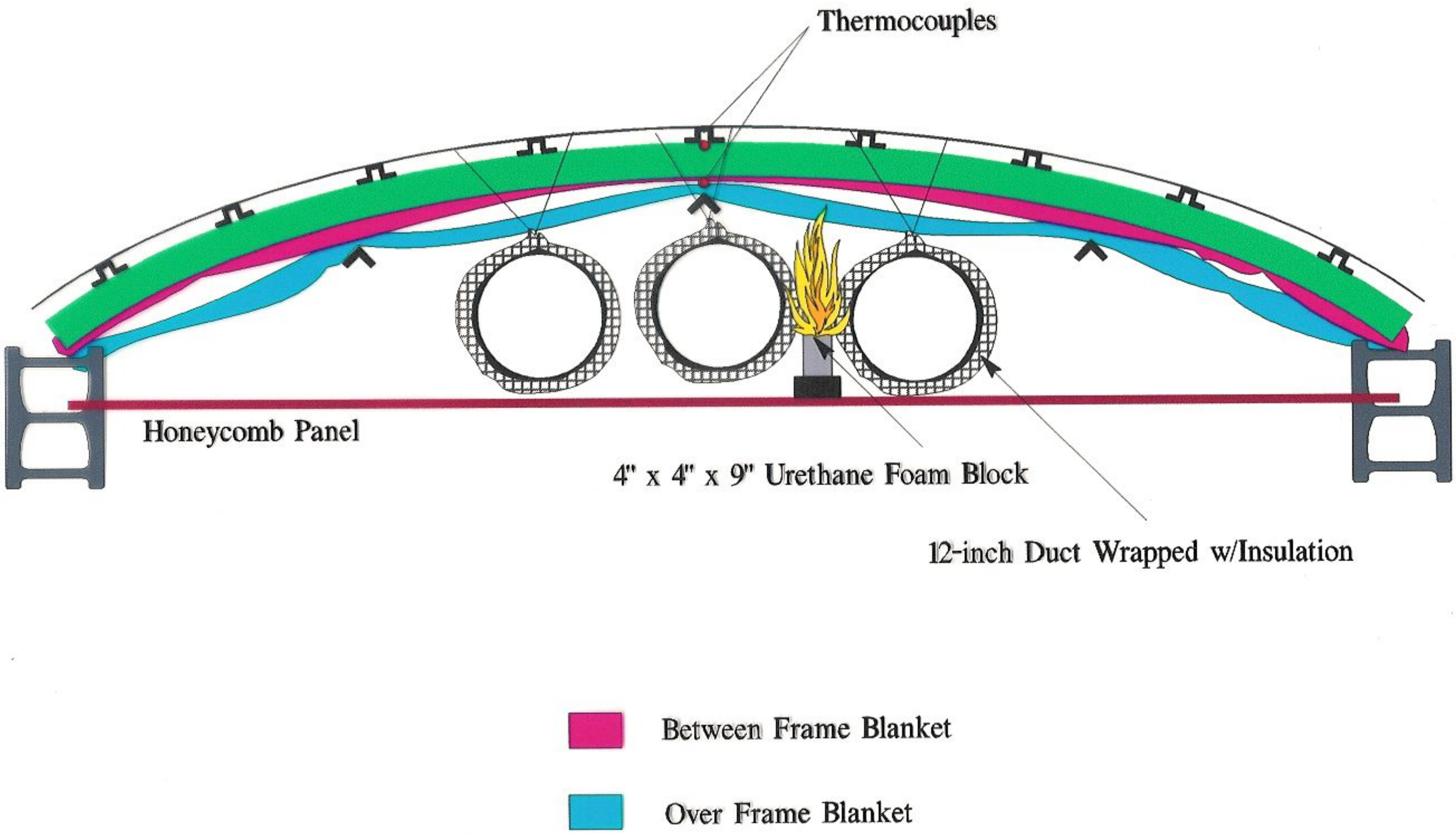


Engine Nacelles

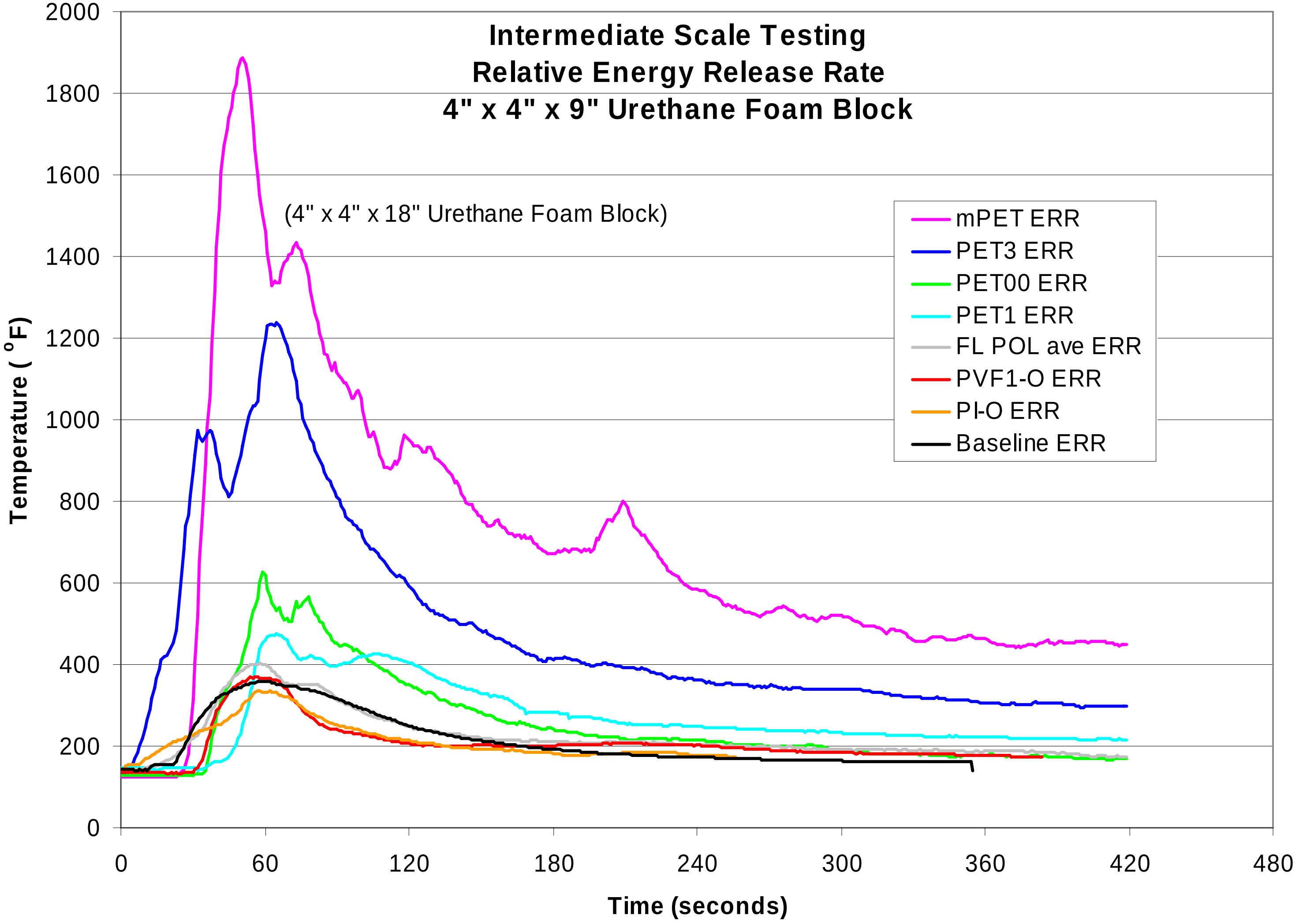
Hand Held Extinguishers

Lavatory Trash Receptacles

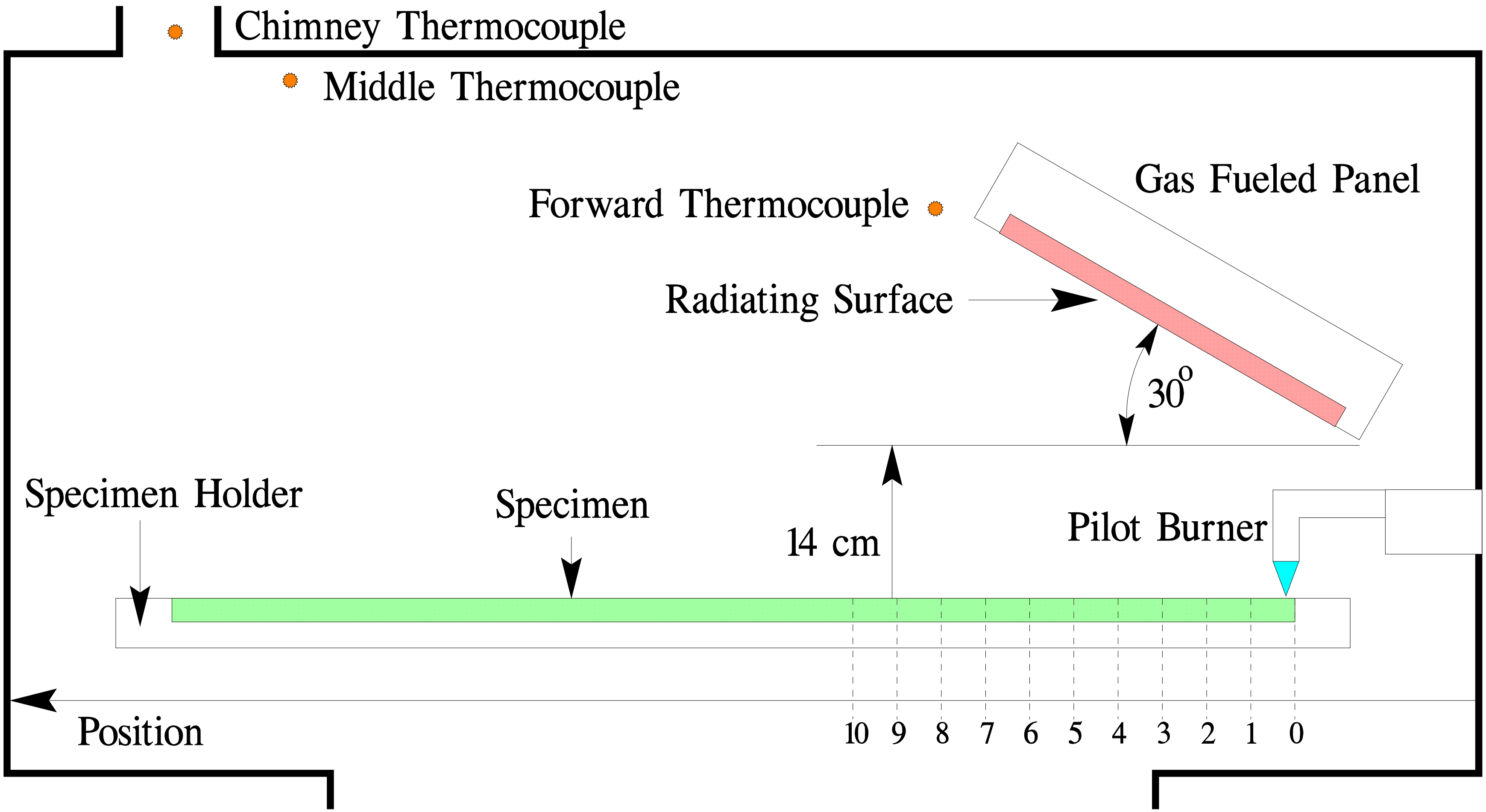
Large-Scale Test Configuration for Measuring Flammability of Insulation Blankets



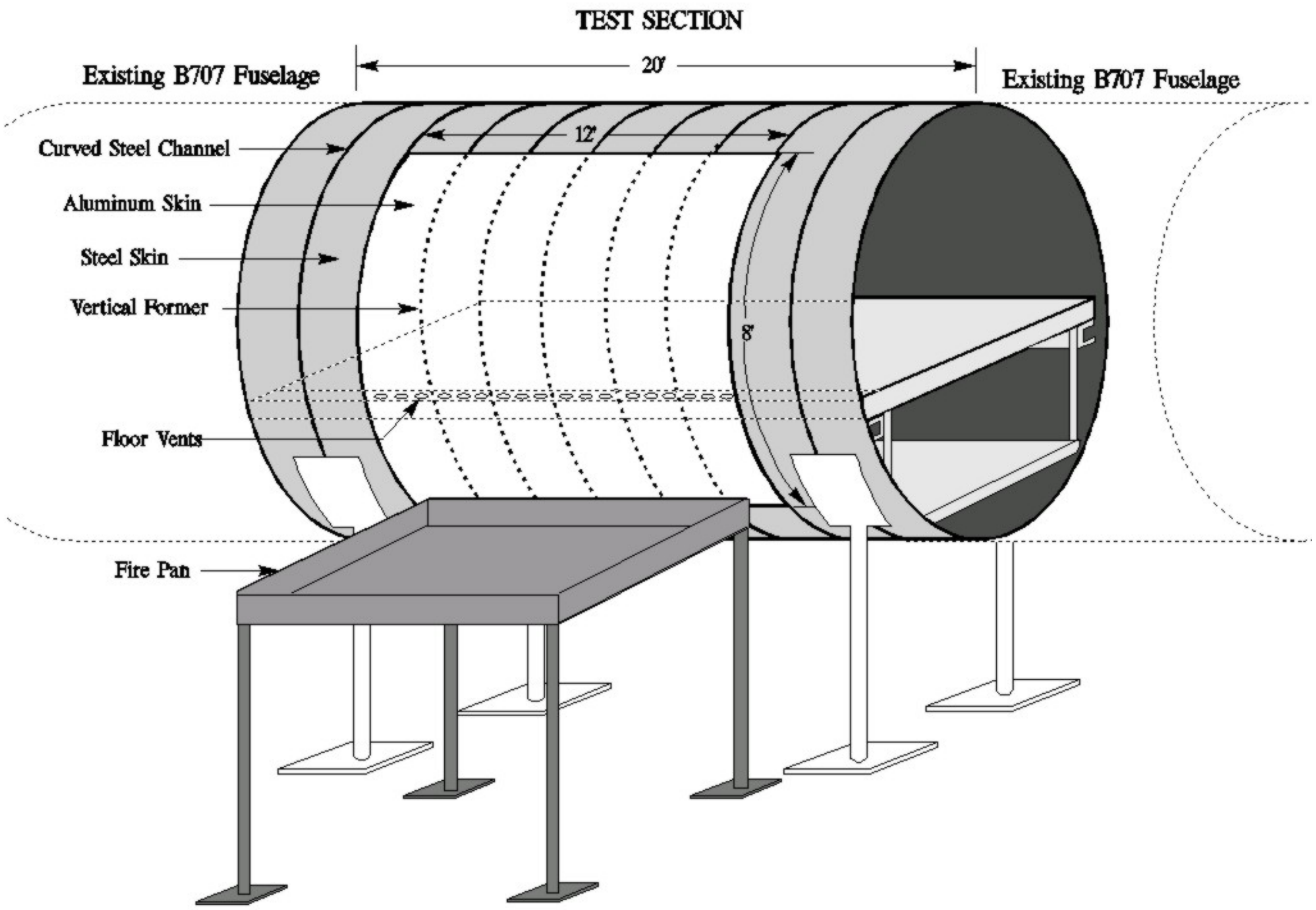
Temperature Profiles of Various Film Materials



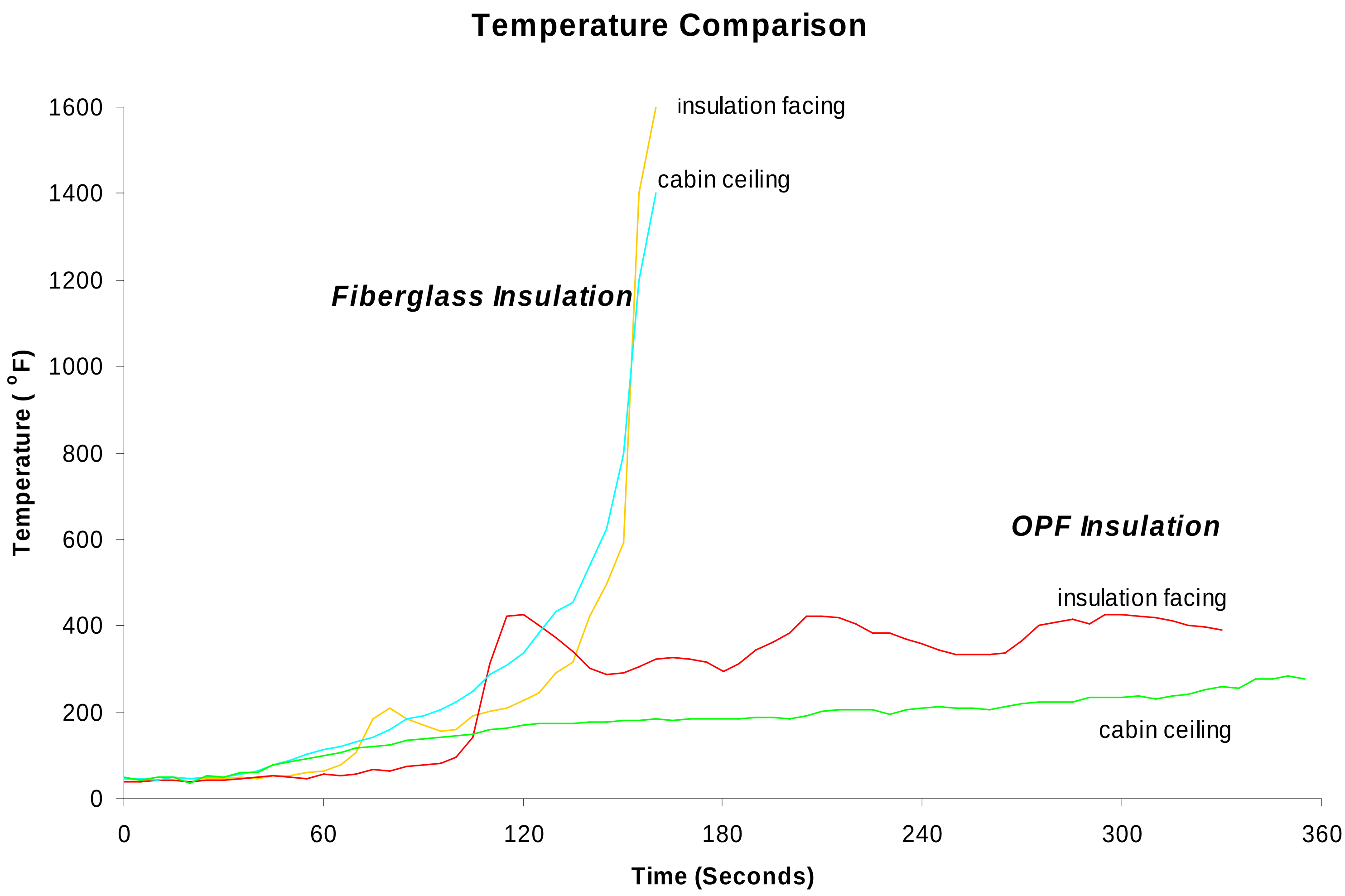
Schematic of Radiant Panel Test Apparatus



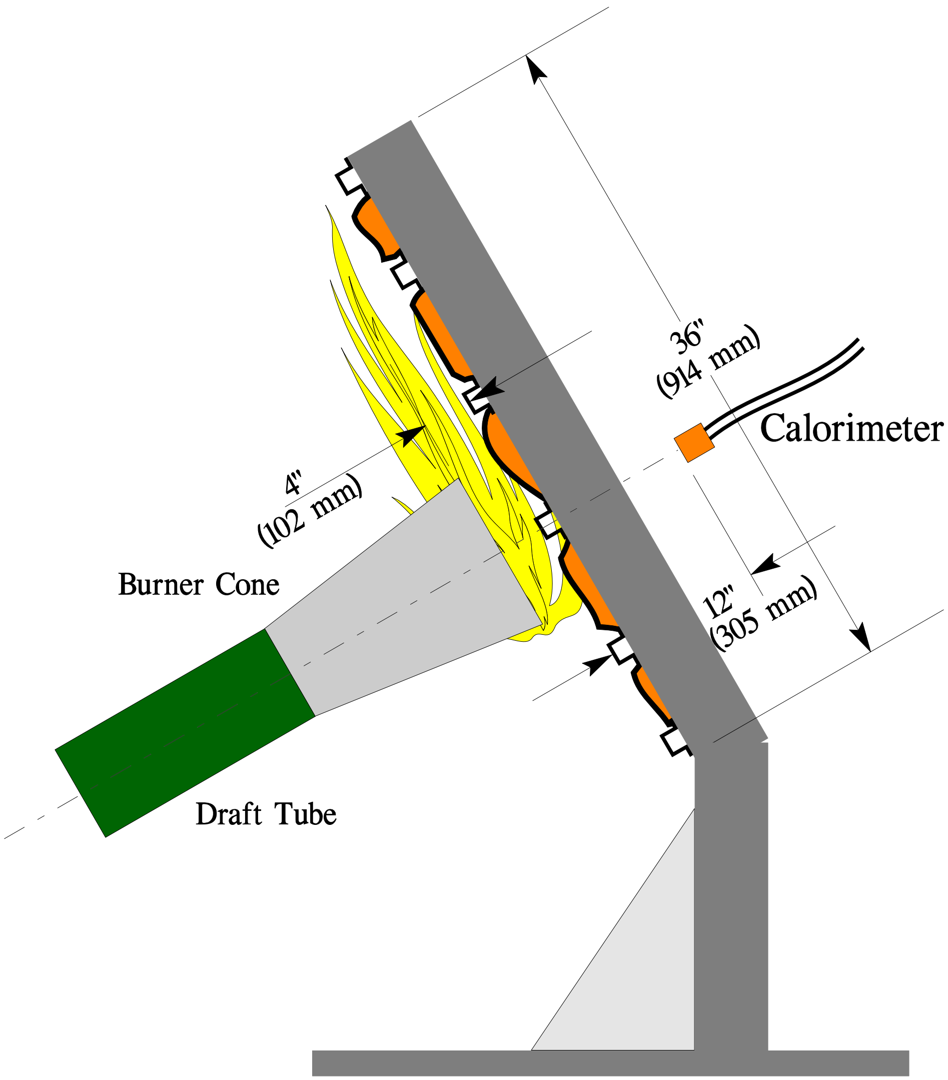
Full-Scale Burnthrough Test Rig Positioned in Aft B707 Fuselage



Temperature Comparison of Current and Alternative Materials



Burnthrough Test Apparatus



2000's

Accident Drivers

- **737, Bangkok, 3/01**
- **727, Bangalore, 5/06**
- **MD82, Dalian, 5/02**
- **A340, Toronto, 8/05**
- **737, Okinawa, 8/07**
- **MD82, Phuket Island, 9/07**

R&D

- **Insulation Advisory Circulars**
  - Radiant Panel
  - Burnthrough
- **Metallized Mylar Insulation/Electrical Arcs**
- **NextGen Burner (Burnthrough)**
- **On-Board Inert Gas Generation System (OBIGGS)**
- **Limiting Oxygen Concentration (LOC)**
- **Lithium Battery Fire Hazards**
- **Fire Research Program**
  - Microscale Combustion Chamber
  - Ultra-Fire Resistant Polymers

A340 Accident

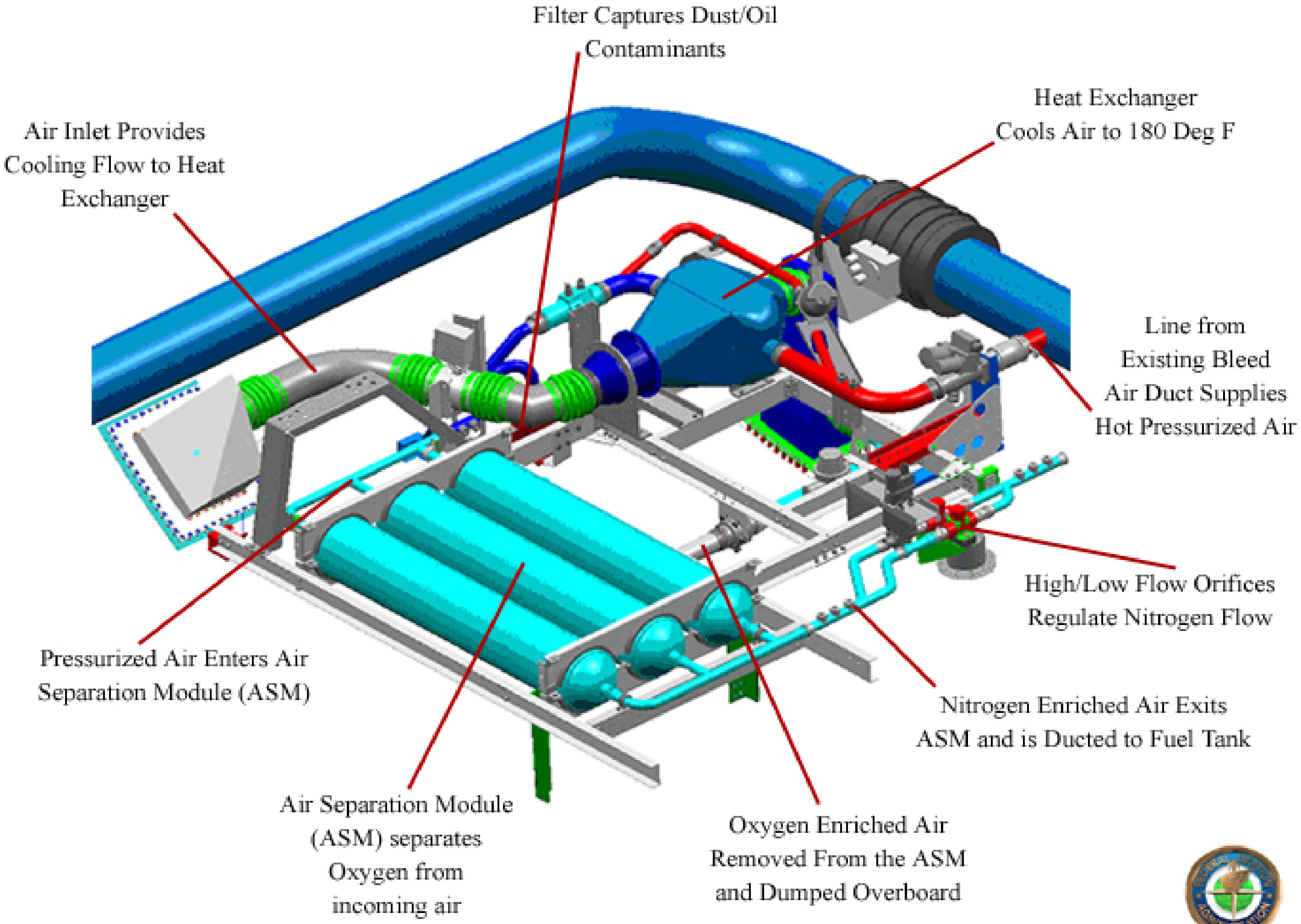
Toronto, Canada; August 2, 2005

MIRACLE ON RUNWAY 24L

China Airlines 737-800

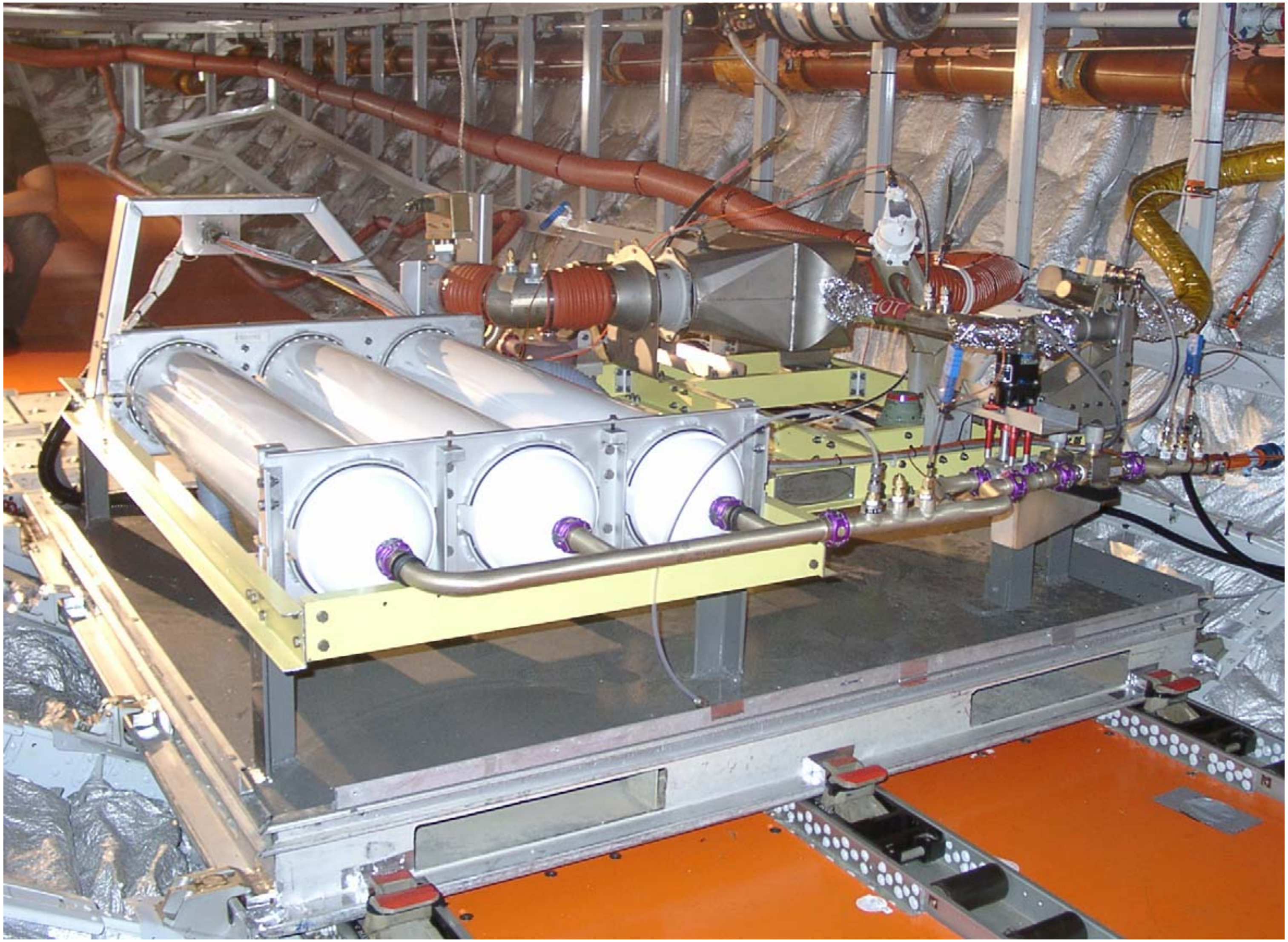
Okinawa; August 20, 2007

Schematic of On-Board Inert Gas Generation System (OBIGGS)

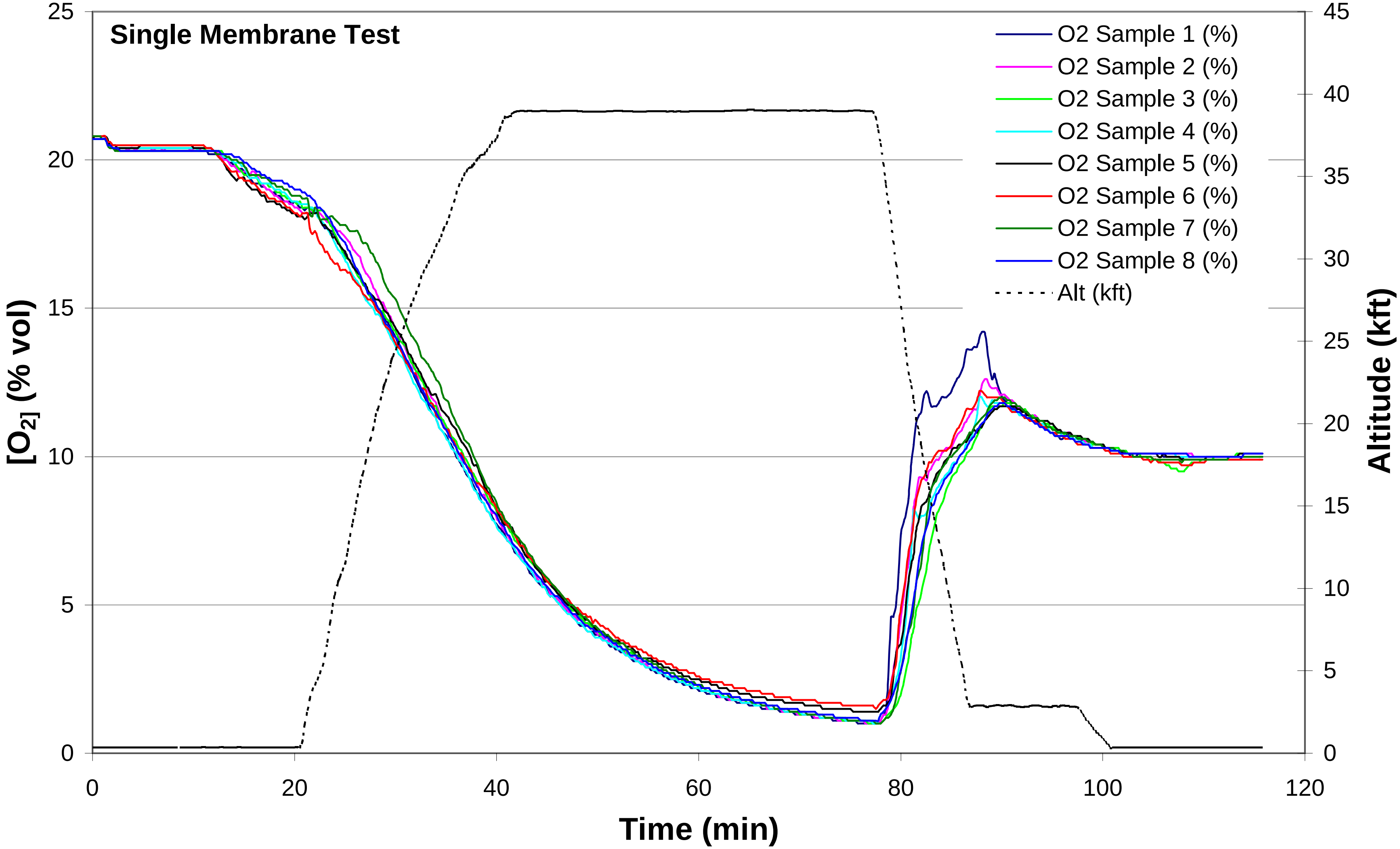


OBIGGS Installed in 747

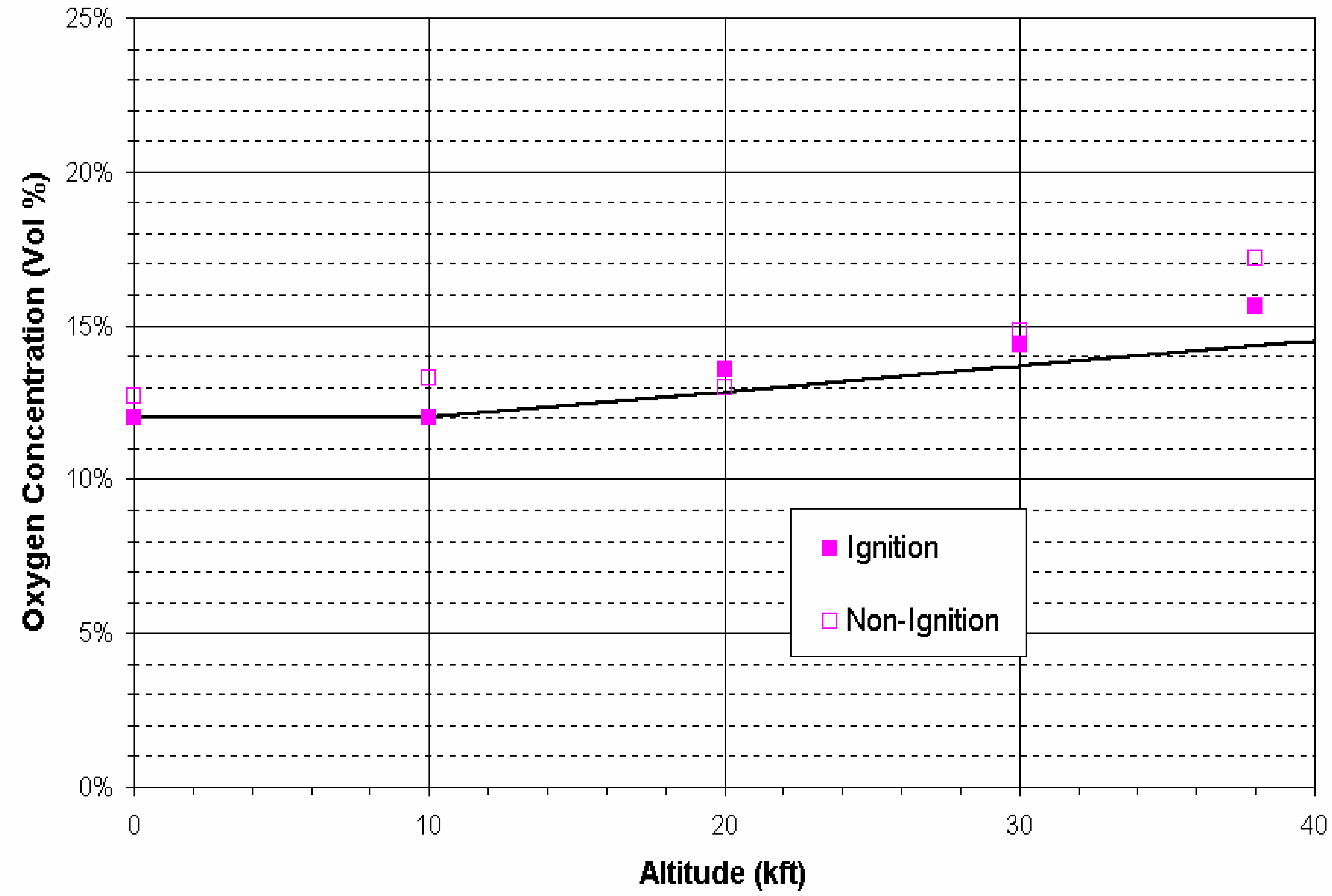
OBIGGS Installed in 320



A320 Oxygen Data



Minimum/Maximum Values for Ignition/Non-Ignition



ASTM Standard Issued for FAA Licensed Flammability Tester
April 1, 2007

Designation: D 7309 – 07

Standard Test Method for Determining Flammability Characteristics of Plastics and Other Solid Materials Using Microscale Combustion Calorimetry[1]

This standard is issued under the fixed designation D 7309; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method, which is similar to thermal analysis techniques, establishes a procedure for determining flammability characteristics of combustible materials such as plastics.

1.2 The test is conducted in a laboratory environment using controlled heating of milligram specimens and complete thermal oxidation of the specimen gases.

1.3 Specimens of known mass are thermally decomposed in an oxygen-free (anaerobic) or oxidizing (aerobic) environment at a constant heating rate between 0.2 and 2 K/s.

1.4 The heat released by the specimen is determined from the mass of oxygen consumed to completely oxidize (combust) the specimen gases.

1.5 The rate of heat released by combustion of the specimen gases produced during controlled thermal or thermoxidative decomposition of the specimen is computed from the rate of oxygen consumption.

1.6 The specimen temperatures over which combustion heat is released are measured.

1.7 The mass of specimen remaining after the test is measured and used to compute the residual mass fraction.

1.8 The specimen shall be a material or composite material in any form (fiber, film, powder, pellet, droplet). This test method has been developed to facilitate material development and research.

1.9 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

1.10 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no ISO equivalent to this test method.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 883 Terminology Relating to Plastics
D 5865 Test Method for Gross Calorific Value of Coal and Coke
E 176 Terminology of Fire Standards
E 1591 Guide for Obtaining Data for Deterministic Fire Models

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms relating to plastics, refer to Terminology D 883.

3.1.2 For definitions of terms relating to fire, refer to Terminology E 176.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *combustion residue, n*—the non-volatile chemical species remaining after controlled thermal oxidative decomposition of a specimen.

3.2.2 *combustion temperature, n*—the specimen temperature at which the specific combustion rate is a maximum during controlled thermal oxidative decomposition.

3.2.3 *controlled heating, n*—a controlled temperature program used to effect thermal decomposition or oxidative thermal decomposition in which the temperature of the specimen is uniform throughout and increases with time at a constant rate.

3.2.4 *controlled thermal (or thermal oxidative) decomposition, n*—thermal (oxidative) decomposition under controlled heating.

3.2.5 *heat release capacity, n*—the maximum specific heat release rate during a controlled thermal decomposition divided by the heating rate in the test.

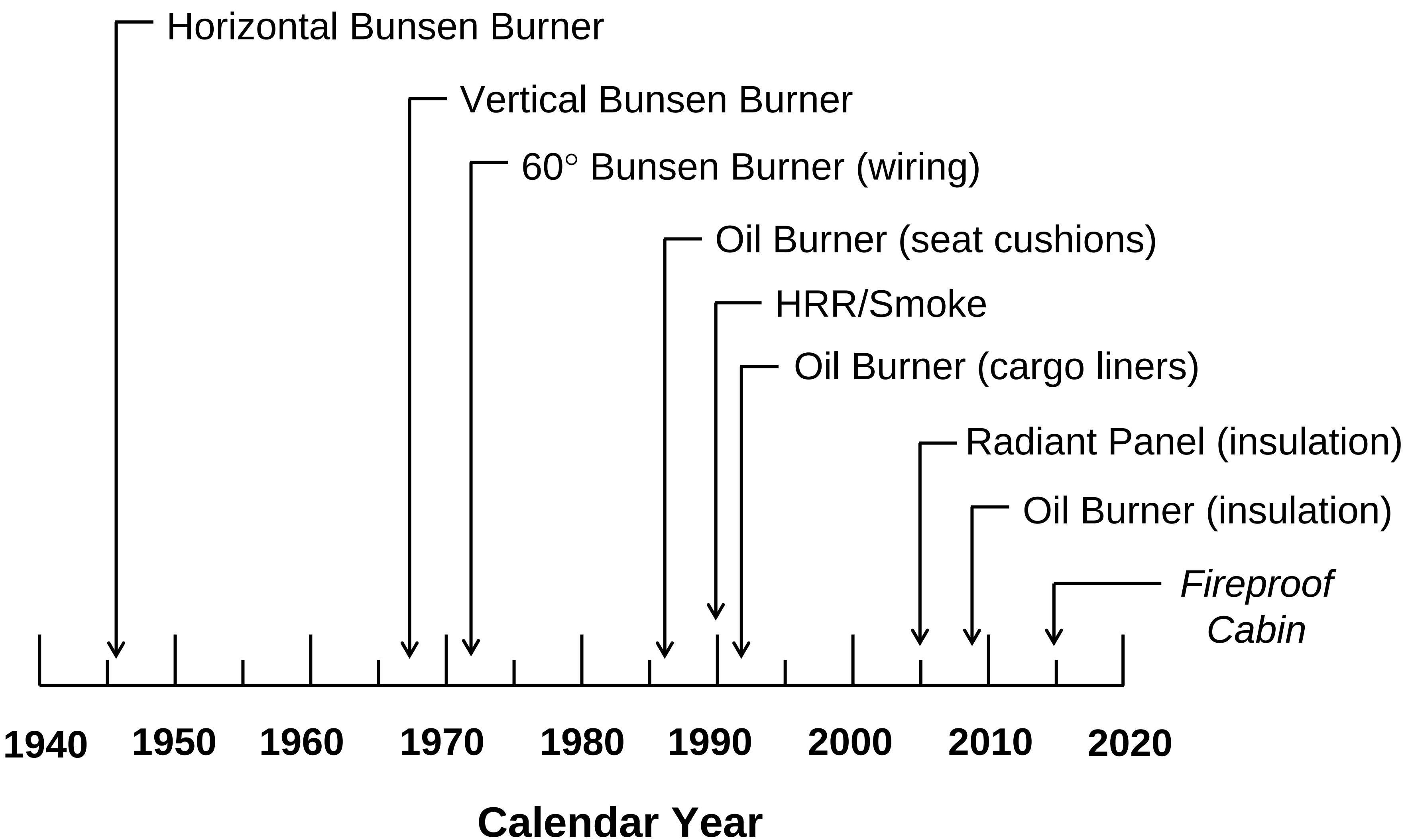
3.2.6 *heating rate, n*—the constant rate of temperature rise of the specimen during the controlled temperature program.

3.2.7 *heat release temperature, n*—the specimen temperature at which the specific heat release rate is a maximum during controlled thermal decomposition.

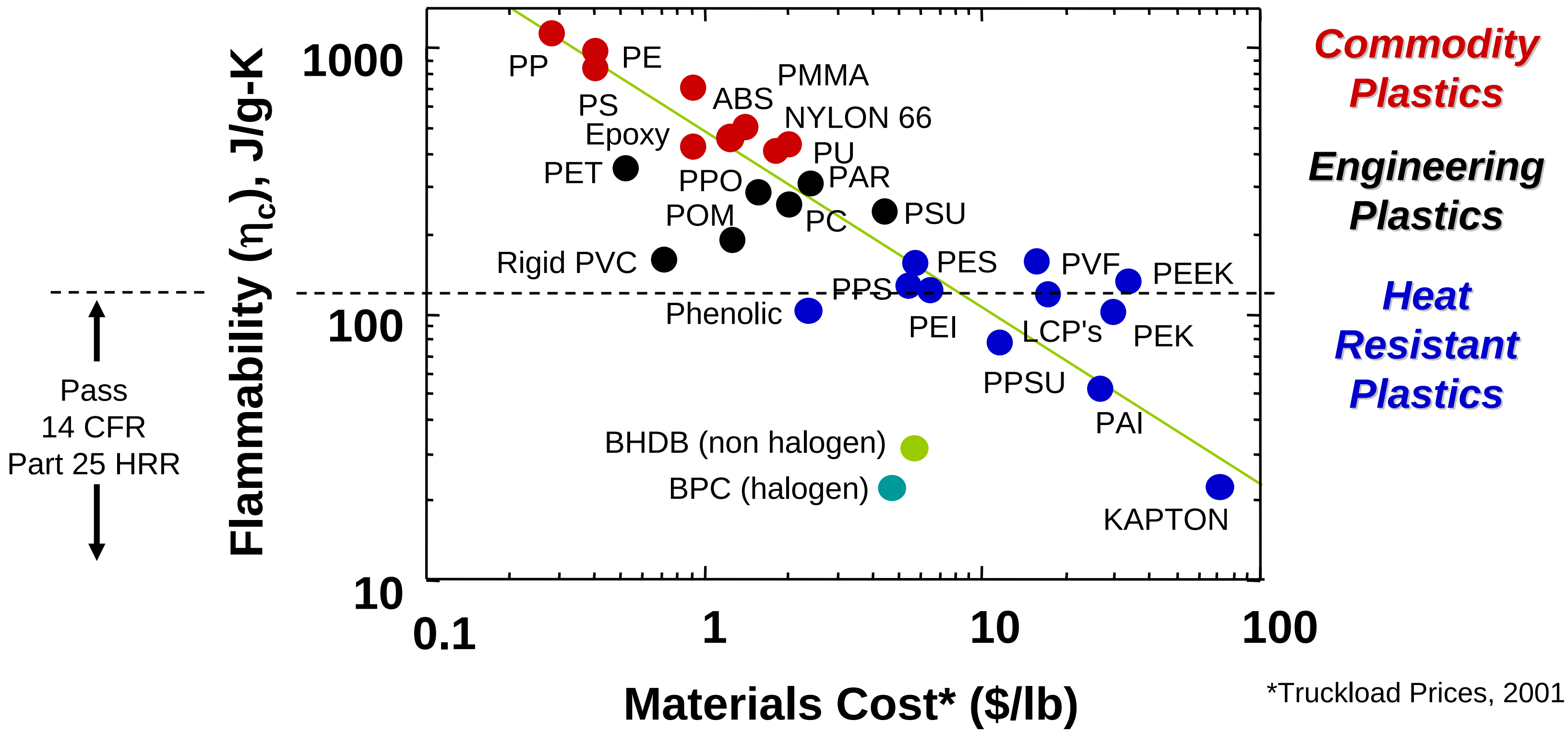
[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties.
Current edition approved April 1, 2007. Published April 2007.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

History of Aircraft Material Flammability Tests

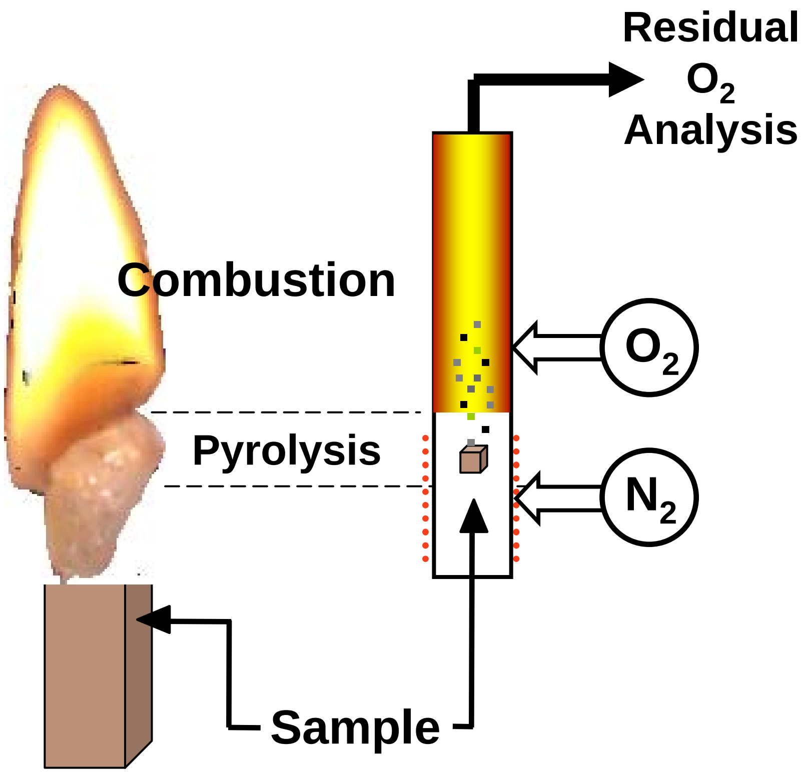


Fire Performance Versus Price of Plastics



*Truckload Prices, 2001

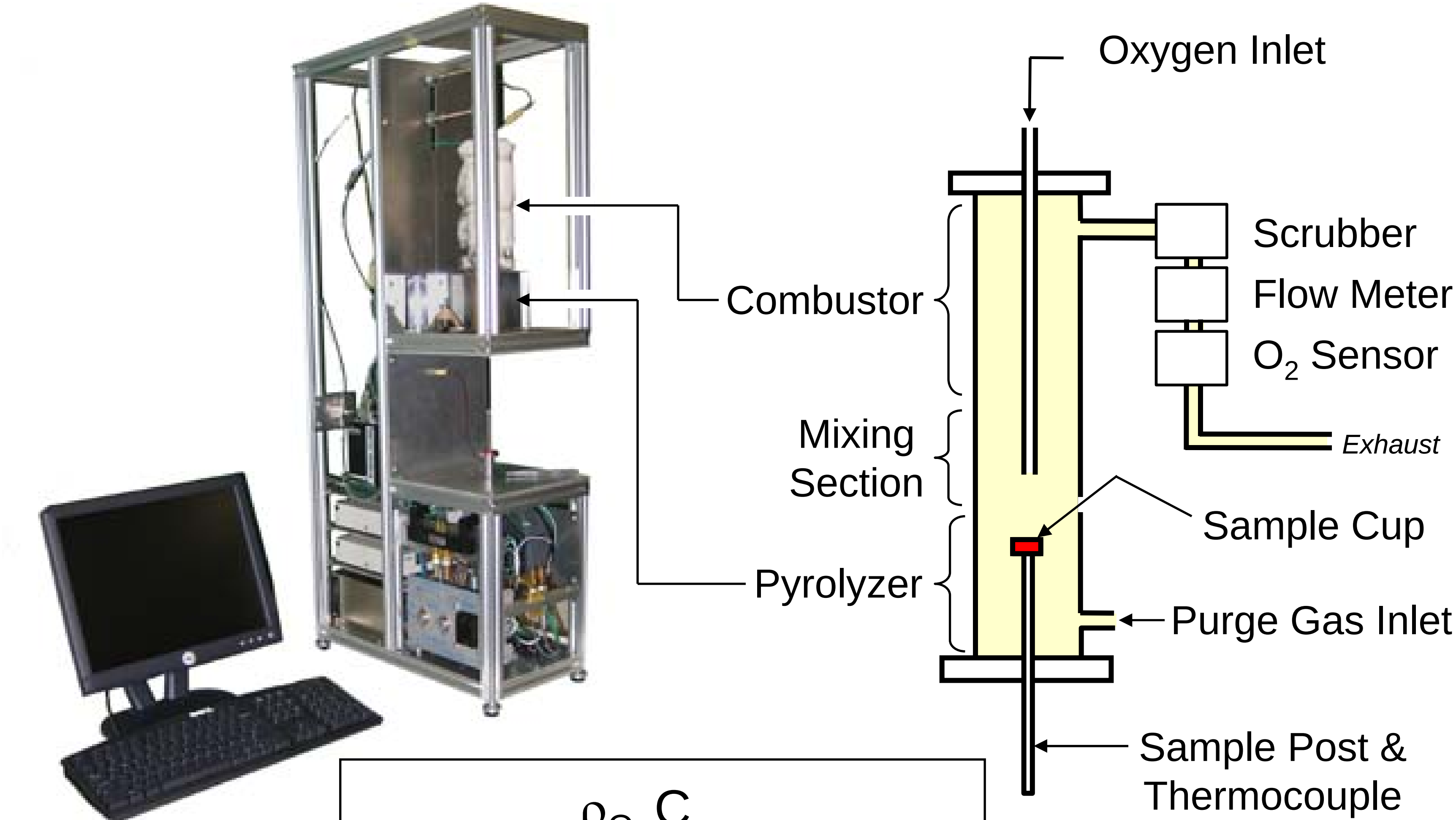
Microscale Combustion Calorimetry Reproduces Elements of Flaming Combustion in Non-flaming Laboratory Test



Flaming Combustion

Microscale Combustion Calorimeter

Microscale Combustion Calorimeter (MCC)



$$Q(t) = \frac{\rho_{O_2} C}{m_0} F[\Delta O_2](t)$$

Future Aircraft Fire Safety R&D

- In-Flight Fire Safety
- Structural Composite Flammability and Fire Safety
- Lithium Batteries and Fuel Cells
- Halon Replacement (Cargo Compartment and Engine)
- Fuel Tank Safety
- Oxygen System Safety
- Fire Research

Ingredients for Success

- **International Cooperation and Exchance of Information**
  - Materials Working Group (45 Meetings since 6/91)
  - Systems Working Group (35 Meetings since 10/93)
  - Cabin Safety Research Technical Working Group
  - 5th Triennial International Conference
- **Fire Test Facilities and Personnel at Technical Center**