5th Triennial International Fire and Cabin Safety Research Conference

Burnthrough Overview

Presented to: Session on Fuselage Burnthrough

By: Tim Marker, FAA Technical Center

Date: October 31, 2007

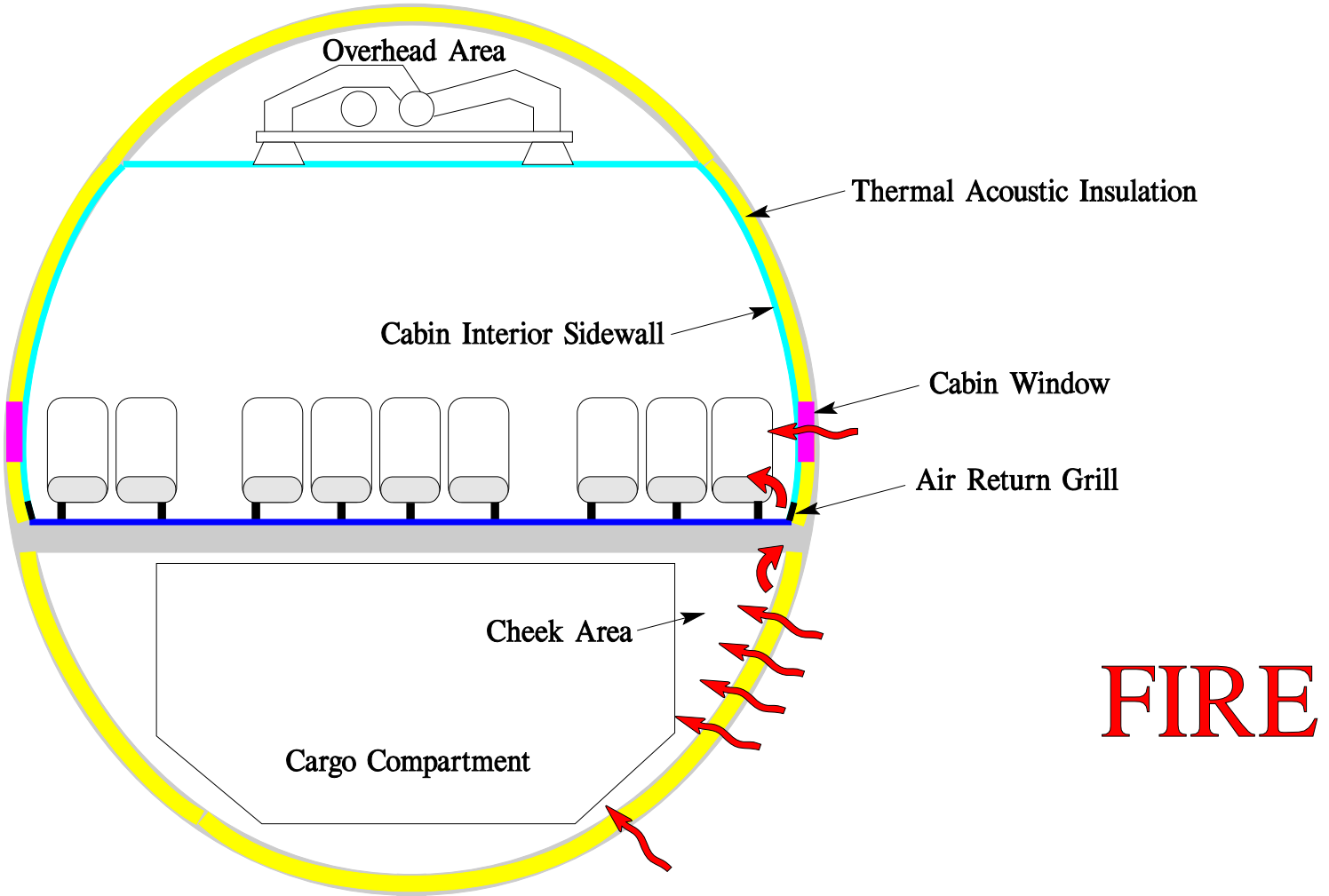
Federal Aviation Administration

What is Burnthrough?

Definition: The penetration of an external, fuel fed fire into the aircraft cabin interior during a crash accident in which the fuselage structure is largely intact.

What is Burnthrough?

What is Burnthrough?



What have past accidents shown?

•Overseas National Airways DC-10, JFK, November 1975

•139 on board/0 fatalities

ONA employees, ferry flight from JFK, birdstrike #3 engine during TO, RTO, #3 engine/pylon fire

What have past accidents shown?

•China Airlines 737, Okinawa, Japan, August 2007

•165 on board/0 fatalities

Right leading edge bolt pierces fuel tank, #2 engine catches fire after landing

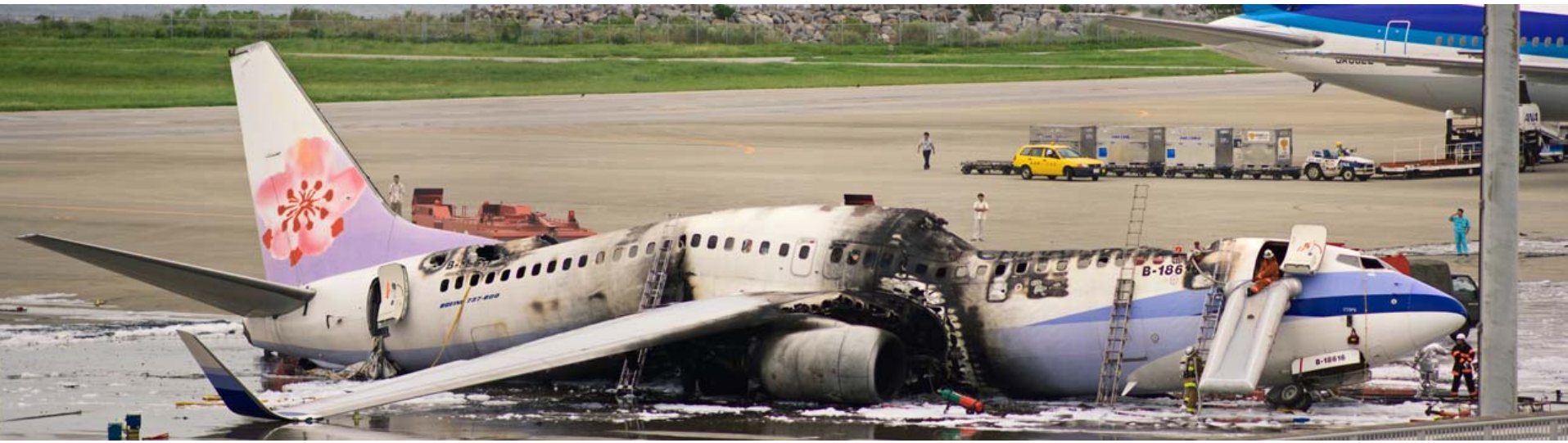
What have past accidents shown?

•China Airlines 737, Okinawa, Japan, August 2007

•165 on board/0 fatalities

Right leading edge bolt pierces fuel tank, #2 engine catches fire after landing

What have past accidents shown?



•China Airlines 737, Okinawa, Japan, August 2007

•165 on board/0 fatalities

Right leading edge bolt pierces fuel tank, #2 engine catches fire after landing

What have past accidents shown?

•Trans World Airlines L-1011, JFK, July 1992

•292 on board/0 fatalities

Faulty angle of attack sensor causes stall warning during rotation, RTO, right wing rear spar crack after touchdown, leaking fuel catches fire

What have past accidents shown?

•Continental Airlines DC-10, LAX, March 1978

•200 on board/2 fatalities

Main landing gear tire explodes during TO, RTO, gear collapse ruptures CW fuel tank

What have past accidents shown?

•Pacific Western Airlines 737, Calgary, March 1984

•118 on board/0 fatalities

Left engine compressor disc failure during TO, fuel tank ruptured, RTO

What have past accidents shown?

•Air France A340, Toronto, August 2005

•309 on board/0 fatalities

What have past accidents shown?

•Spantax Airlines DC-10, Malaga, Spain, September 1982

•393 on board/51 fatalities

Runway over-run following aborted take-off due to tire vibration, fuselage break-up w/fire

What have past accidents shown?

•British AirTours 737, Manchester, England, August 1985

•137 on board/55 fatalities

Left engine compressor disc failure during TO, fuel tank ruptured, RTO

What have past accidents shown?

•1-2-Go Airlines MD-82, Phuket, Thailand, September 2007

•130 on board/89 fatalities

Wind-shear, gear-up landing, runway over-run during storm, fuselage break-up w/fire

What have past accidents shown?

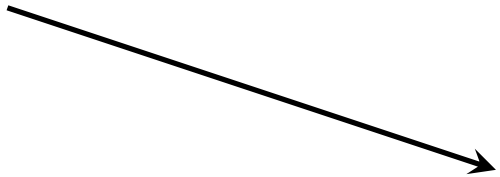
- **Review of accident data suggests outcome is largely scenario dependant;**

- **Factors such as available escape exits, fire size and position, wind direction, condition of passengers, passenger load, etc. all critical in occupant survivability.**

How do we fix the problem?

Accident Information

(Problem)



Reasonable Fix

(Solution)

Safety Benefit Analysis - 1999

DOT/FAA/AR-99/57

Office of Aviation Research
Washington, D.C. 20591

CAA Paper 99003
Civil Aviation Authority
London, England

Fuselage Burnthrough Protection for Increased Postcrash Occupant Survivability: Safety Benefit Analysis Based on Past Accidents

September 1999

Final Report

This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

U.S. Department of Transportation
Federal Aviation Administration

Civil Aviation Authority
London, England

NOTICE

Safety Benefit Analysis - 1999

Seventeen accidents to Transport Category aircraft were identified during the period from 1966 to 1993 where occupant fire injuries were sustained, and fire penetration of the passenger cabin occurred as a result of ground fires. Each accident was divided into scenarios where it was assessed that there was a similar level of threat to the occupants. A mathematical technique was used to model each accident scenario and a Monte Carlo simulation was used to predict a high, median, and low value for the benefits assessed.

A range of burnthrough protection times was used, and results are presented for protection times from 30 seconds up to 8 minutes. Eight minutes was chosen to encompass the highest level of protection thought to be practical. The reduction in the structural strength of the fuselage as a result of a pool fire appears to have a limited effect on occupant survival. If this is confirmed it is likely to result in a greater opportunity to find cost beneficial solutions to hardening aircraft against pool fires.

The analysis was carried out for the aircraft standards at the time of the accident and assessed for the aircraft if it were configured to the latest airworthiness requirements.

Fire hardening of fuselages will provide benefits in terms of enhanced occupant survival and may be found to be cost beneficial if low-cost solutions can be found. The maximum number of lives saved per year, over the period covered by the data, was assessed to be 12.5 for the aircraft in its actual configuration and 10.5 for the aircraft configured to later airworthiness requirements.

Safety Benefit Analysis - 1999

Key findings

- **1966 to 1993 (17 burnthrough accidents)**
- **“Fire hardening of fuselages will provide benefits in terms of enhanced occupant survival and may be cost beneficial if low cost solutions can be found”**
- **12.5 Lives saved /yr (actual aircraft config)**
- **10.5 Lives saved/yr (updated aircraft config)**

Safety Benefit Analysis - 2003

A benefit analysis has been carried out to derive the life saving potential of a Cabin Water Spray system in conjunction with enhanced Fuselage Burnthrough Protection from large external pool fires. The effects of fire and evacuation related requirements that were introduced after the accident date have also been taken into account.

All benefits derived are based on the number of lives saved for the world fleet of western-built aircraft type certificated for more than 30 seats and are relative to the period 1967 to 1996. Two configurations of Cabin Water Spray system have been considered in the benefit analysis - a Modular and a Singular system. It is assumed that a Modular system would consist of three separate water supplies located in the front, mid and rear sections of the fuselage and would be activated only in the areas affected by fire. A Singular system would have only one source of supply located in the centre section of the fuselage. It would provide benefit in this area should the nose and/or tail sections became detached in the accident. Benefit has been determined for aircraft configurations having either enhanced Fuselage Burnthrough Protection or a Cabin Water Spray System. In addition, the study reassesses the benefit from Cabin Water Sprays on aircraft already configured with enhanced Fuselage Burnthrough Protection. The analysis has been accomplished by analysing past accidents to western-built aircraft over the period 1967 to 1996. Two methodologies were used to determine the total assessed benefit for all accidents studied. The first was based on an assessment of the number of lives saved in each accident from which a determination was made of the average number of lives saved per year and its likely range. The second method was to determine the rate of occurrence per year of the number of accidents from which the improvements considered might yield benefit. The merits of each method are discussed and it was considered that the best prediction of benefit is that derived from Method 2. Enhanced Fuselage Burnthrough Protection has been reassessed and the life saving benefit increased from that previously estimated. The number of lives saved per year is estimated to be approximately 12.

Safety Benefit Analysis - 2003

- **Accidents from 1967 to 1996 studied**

- **“Enhanced fuselage burnthrough protection has been reassessed and the life saving benefit increased from that previously estimated. The number of lives saved per year is estimated to be approximately 12.”**

What is the best approach?

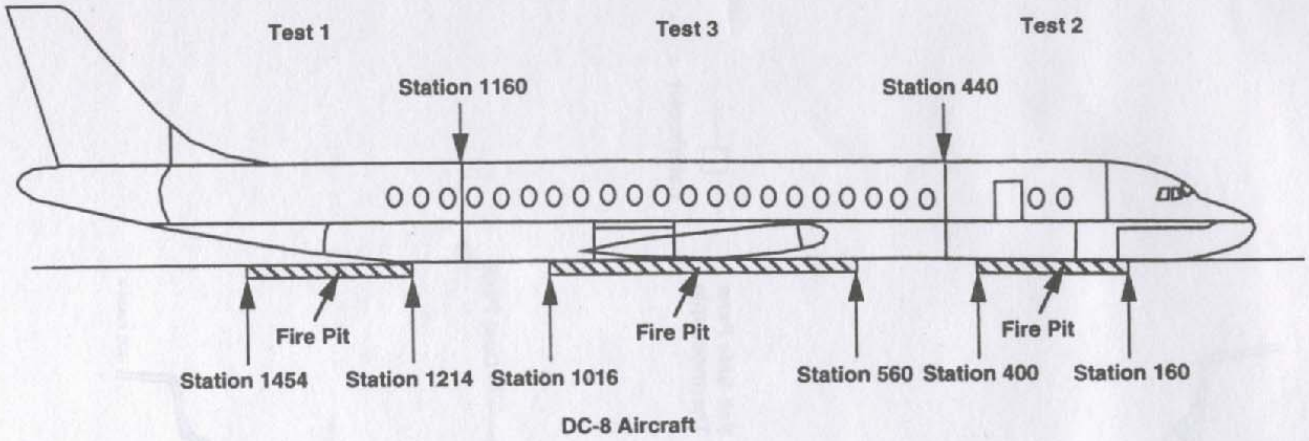
- **How can we increase occupant survivability during an impact-survivable, postcrash fire accident?**

1. reduce spread of fire into and inside cabin,

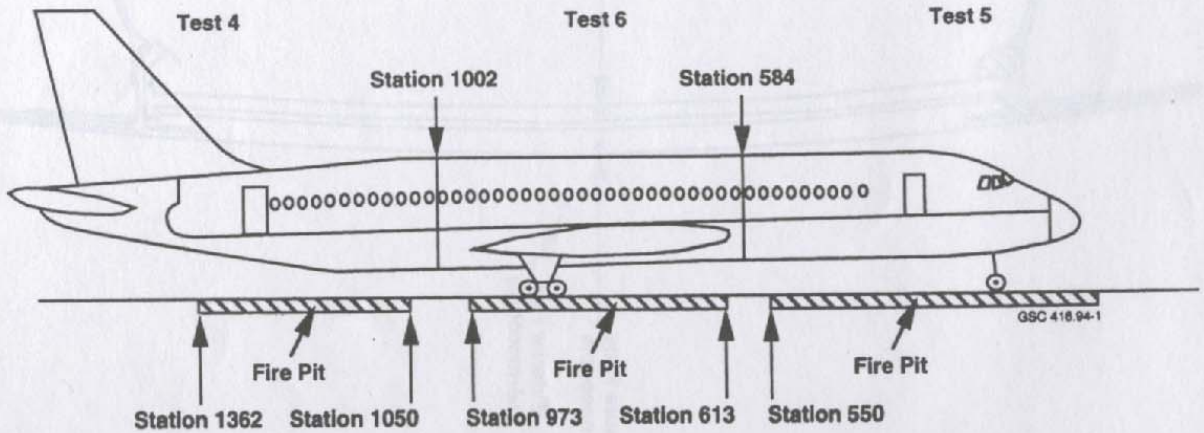
2. increase evacuation rate

What's been done??

Surplus Aircraft Testing

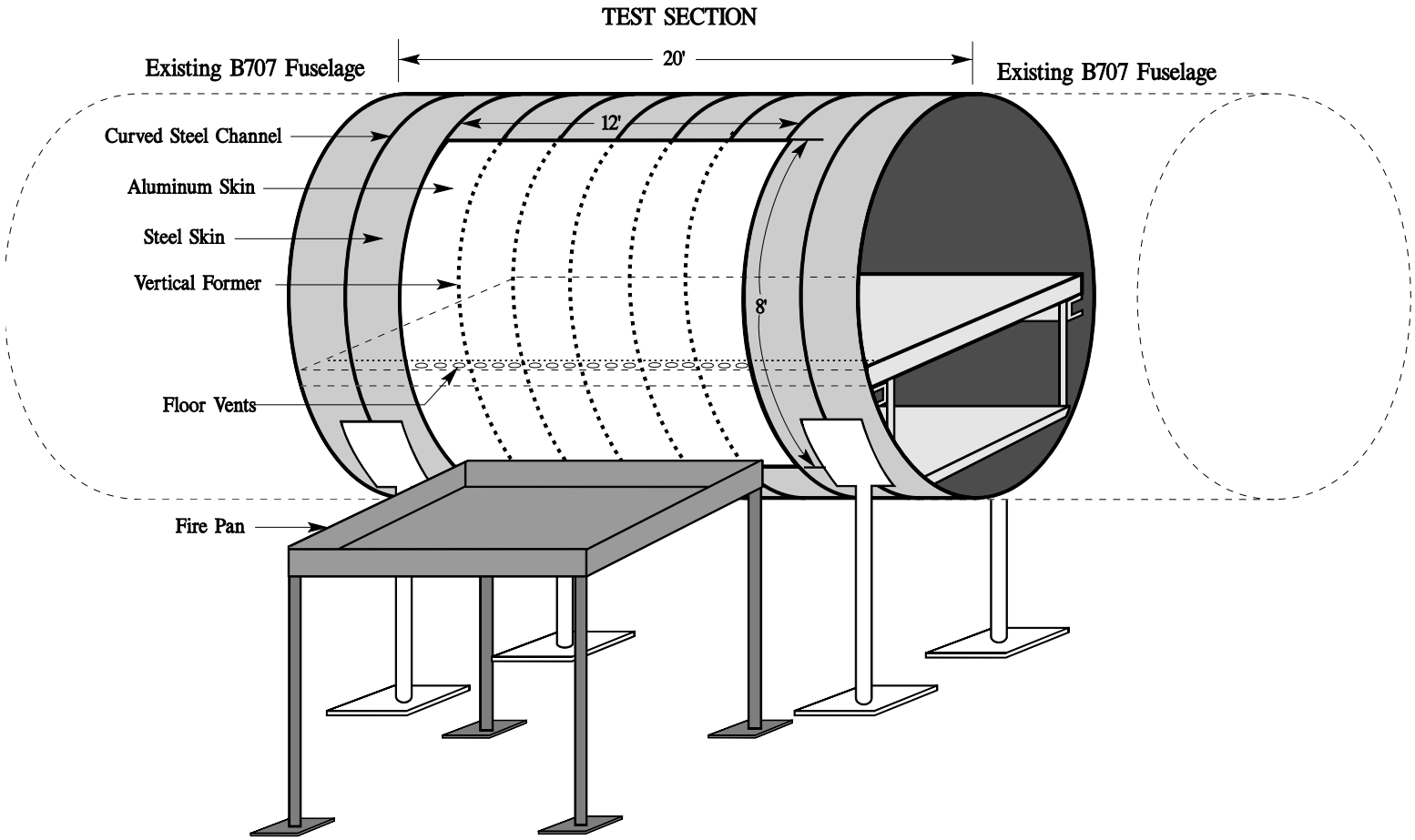


DC-8 Aircraft



Convair 880 Aircraft

Full-Scale Test Apparatus



Full-Scale Testing

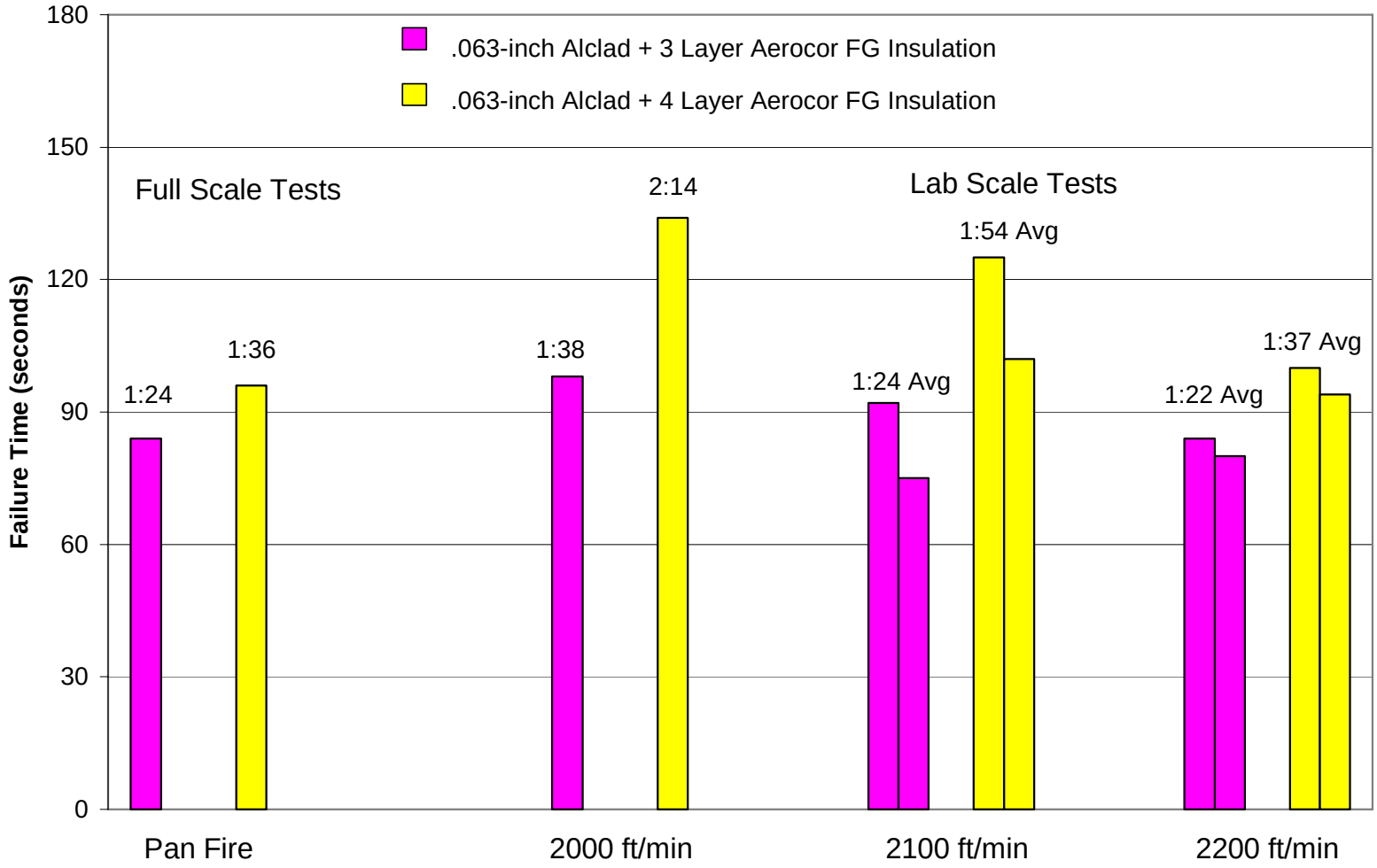
Laboratory-Scale Test Method

Correlation of Results

?

=

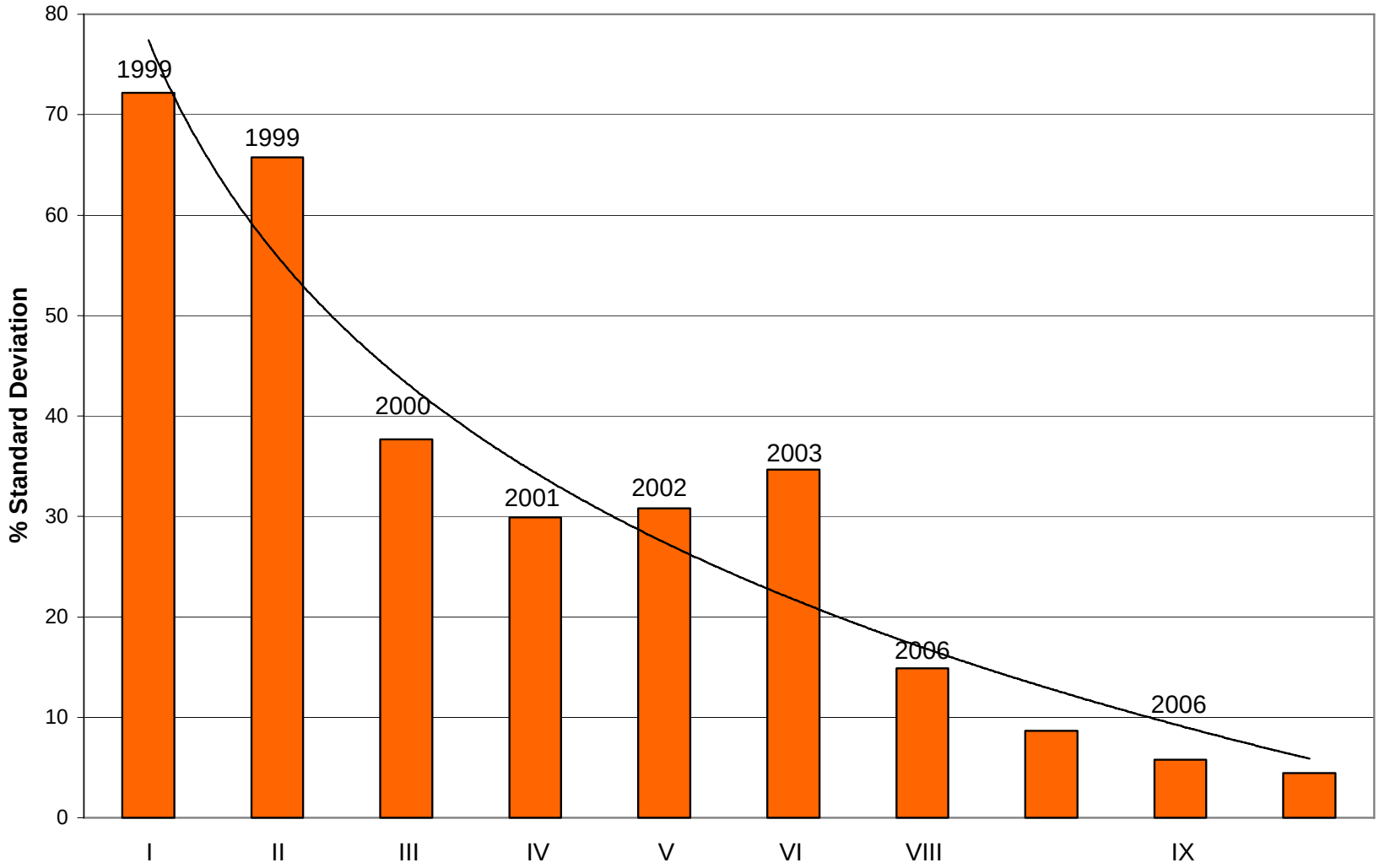
Correlation of Lab- and Full-Scale



Round Robin Testing

- **Purpose: To identify and correct deficiencies in burnthrough testing labs throughout the world.**
- **Methodology: Identical test samples are prepared and distributed to participating labs for testing. Results tabulated and presented by FAATC.**

Round Robin Testing



Round Robin Testing

- **Impact on test method: RR testing has been instrumental in identifying problem areas with the test apparatus. Results have indicated a steady increase in correlation of data between labs.**

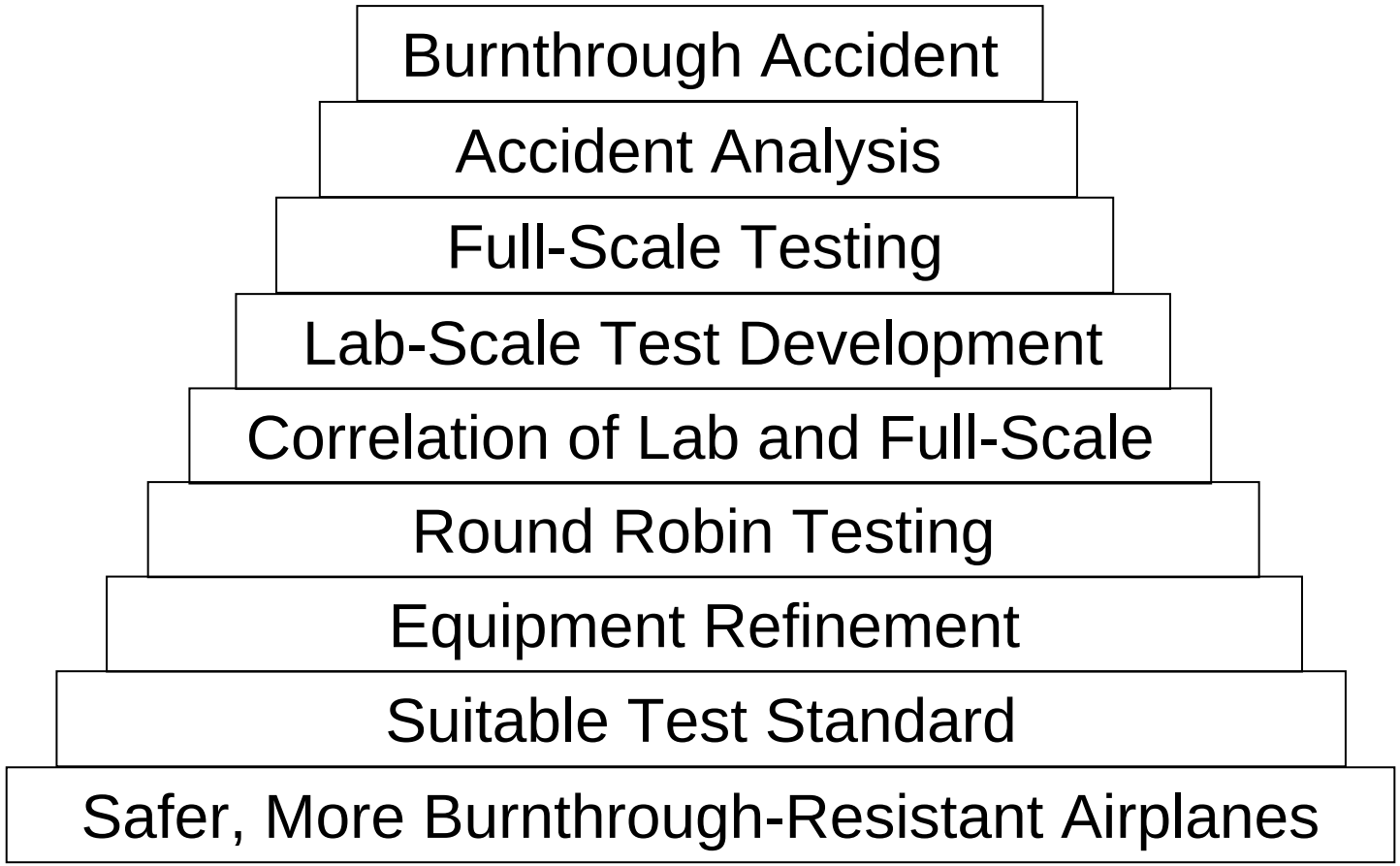
Improved Test Equipment

- **Impact on test method: Improved sonic "Nex-Gen" burner has the ability to provide more consistent results.**
- **Nex-Gen burner also fills void for discontinued burner manufactured by Park Electric Motors.**
- **Greater understanding of burner fuel nozzles has led to increased consistency in test results.**

Suitable Calibration Materials

- **Use of test materials that are engineered to fail in the appropriate range has helped isolate problems in test equipment.**

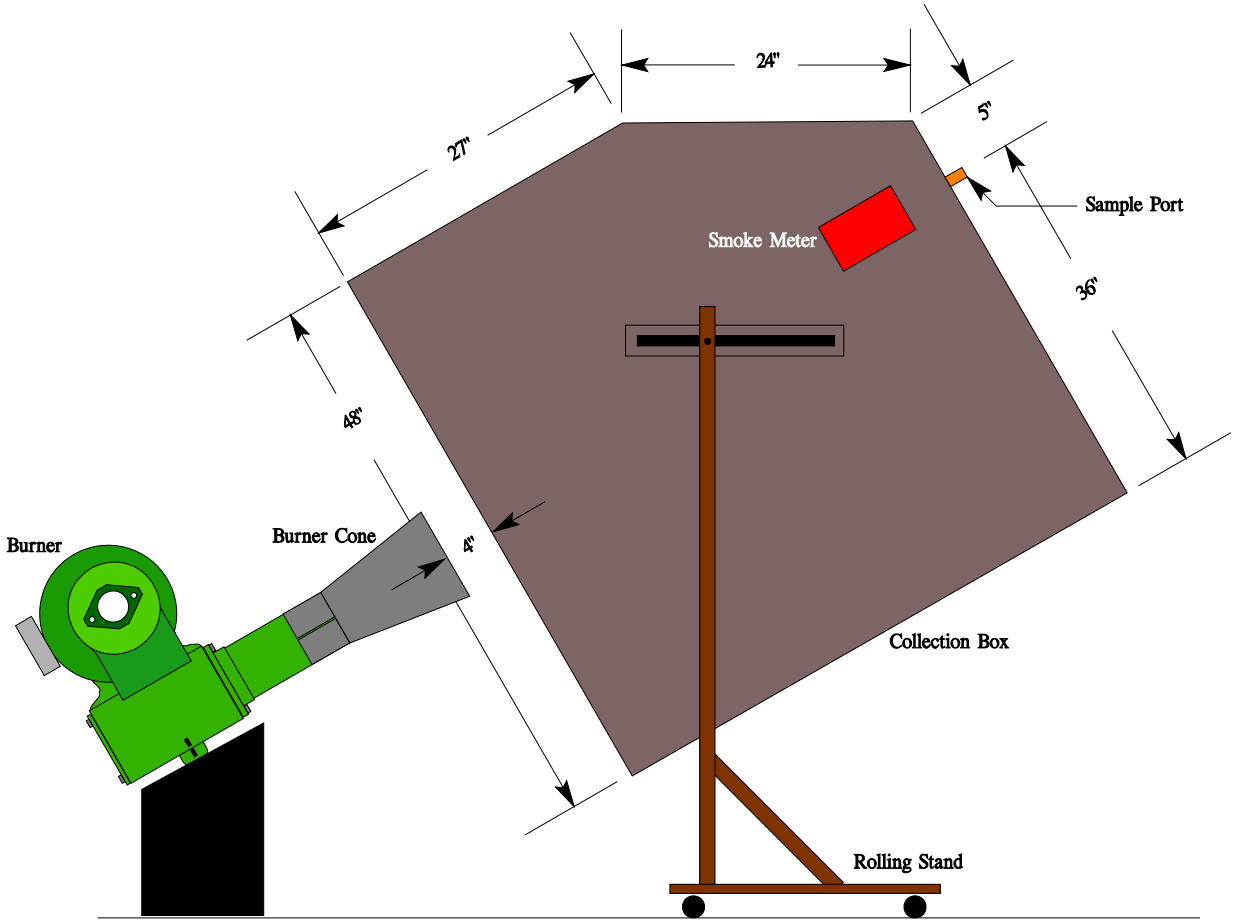
Project Evolution



What else needs to be done??

Non-Typical Fuselage Configurations

Development of Lab-Scale Toxicity Test For Decomposition Products During a Postcrash Fire

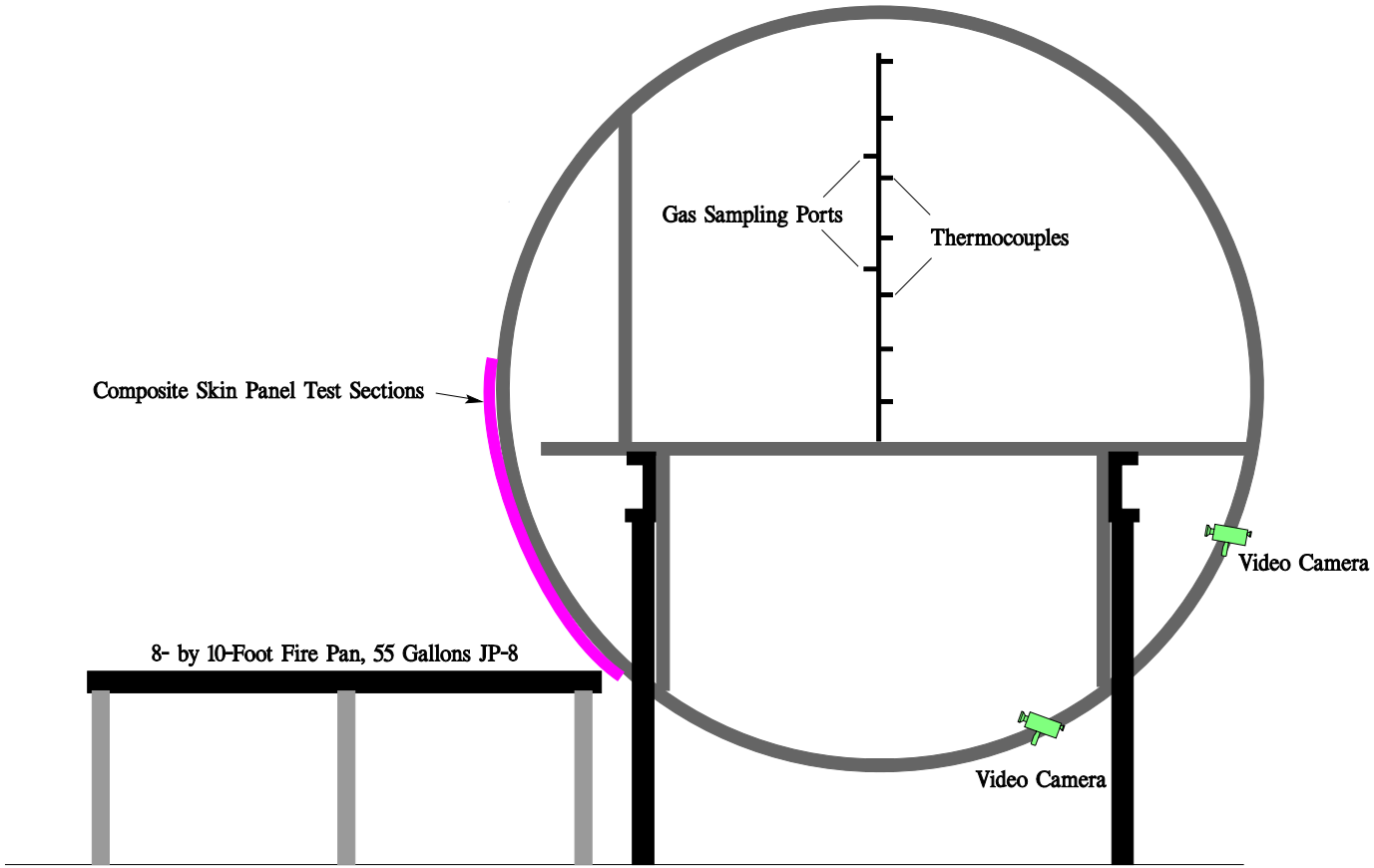


Development of Lab-Scale Toxicity Test For Decomposition Products During a Postcrash Fire

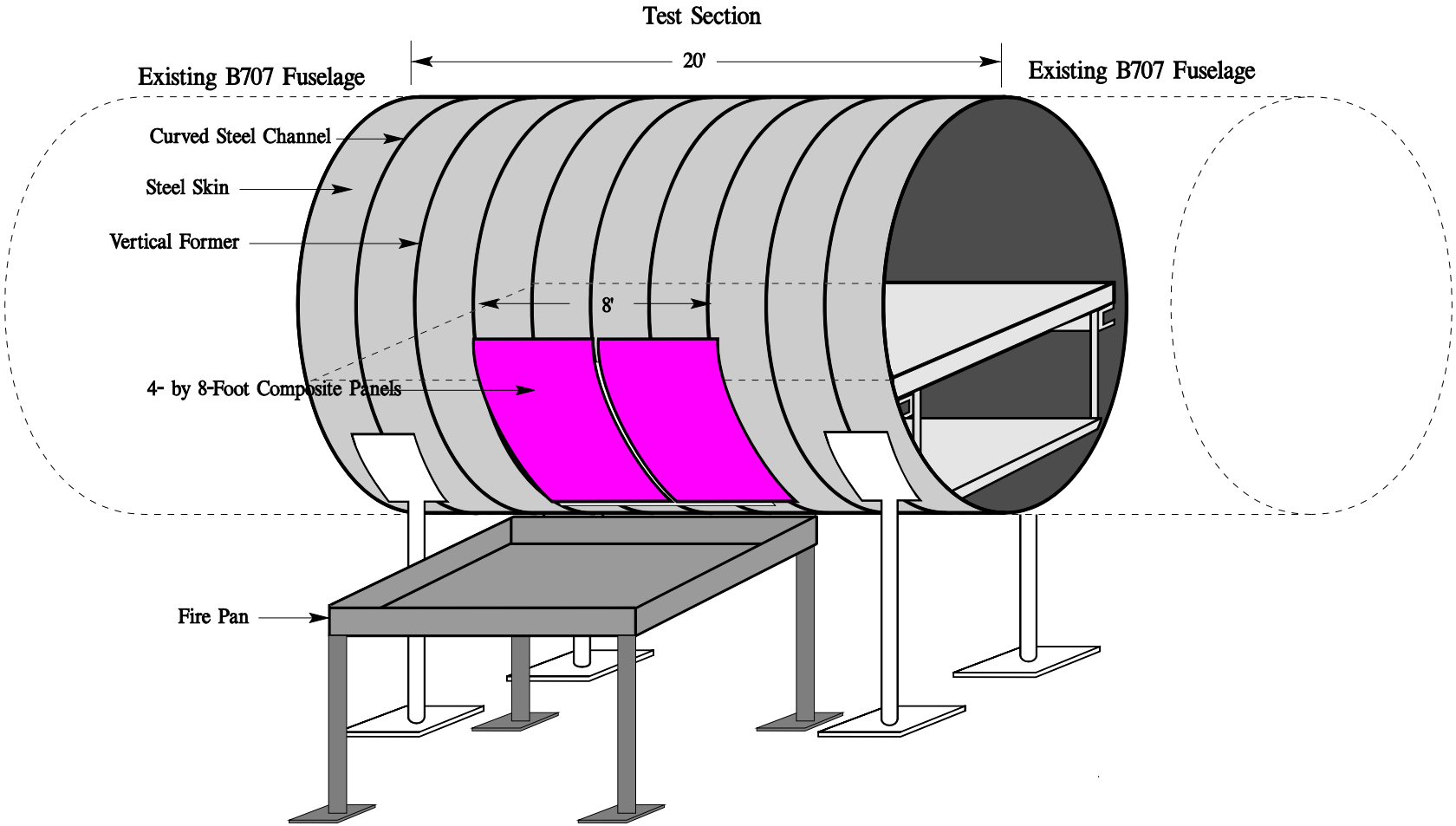
It is anticipated that this test method could be used to evaluate the potential toxicity of insulation constructions and innovations meeting the new burnthrough test requirements, in order to ensure that an adverse condition will not result inside the fuselage, despite the high burnthrough performance associated with a particular system.

This test method could also be used to evaluate the toxic contribution of the basic fuselage structure, whenever a nonmetallic material is used as the primary component.

Full-Scale Test Article for Determining Decomposition Products Entering Cabin from Non-Exposed Skin Side



Full-Scale Test Article for Determining Decomposition Products Entering Cabin from Non-Exposed Skin Side



Correlation of Full-and Lab-Scale Toxicity Tests

Several preliminary lab-scale tests completed using various burnthrough resistant materials.

Additional full-scale tests required to determine the correlation between full- and lab-scale tests.

Full-scale tests to focus on the amount of toxic gas decomposition products entering cabin area from the non-exposed skin side.

Burnthrough: Way Forward

- Continue development and distribution of “sonic” burners used in burnthrough test.
- Continue lab “checkout” process to assist certification personnel.
- Complete final version of Advisory Circular.
- Complete full-scale toxicity testing.
- Develop appropriate pass/fail criteria for laboratory scale toxicity test.