Vertical Bunsen Burner Test

The Evaluation of the 12-seconds Vertical Bunsen Burner Test Appendix F Part I(a)(4) to Part 25




INTERNATIONAL AIRCRAFT MATERIALS FIRE TEST WORKING GROUP
WJH FAA Technical Center
John W. Reinhardt
Fire Safety Section, AAR-422 Atlantic City Int'l Airport, New Jersey 08405

Outline

- Objective
- Introduction
- Technical Approach for Evaluation Program
- Test Results
- Conclusion
- Recommendations
- On-going Work
- Acknowledgement

Objective

To determine if the current FAA compliance test (12-sec Vertical Bunsen Burner Test), which is used to certify air conditioning ducts and electrical conduits, is comprehensive enough to differentiate between a fire worthy and non-fire worthy material as expected in today's aviation industry.

Introduction

- Because of improvement in material technology and the interest of minimizing hidden fire threats in commercial aircraft, the FAA re-examined one of its required certification tests.
- The re-examined test was the 12-seconds vertical Bunsen burner test (found in the Code of Federal Regulations Title 14 Chapter I Part 25 Appendix F Part I (a)(4)) which is use to certify components like ducts and conduits.

Fire in Cheek Area AirTran DC-9-32, Atlanta, 11/29/00

Fire in Bulkhead AirTran DC-9-32, Greensboro, 8/8/00

Approach

The approach selected to determine the effectiveness of the 12-sec Vertical Bunsen Burner test was by conducting a testing program.

- 12 sec Vertical Bunsen Burner Test (Baseline)
- Intermediate-Scale Test
- Heat Release Test
- Smoke Test
- Micro-Scale Calorimeter Test
- Radiant Panel Test

Approach

12-Seconds Vertical Bunsen Burner Test:

Test Protocol: Chapter 1 of DOT/FAA/CT-89/15 Aircraft Material Fire Test Handbook

Sample Size: 75mm x 305mm

Heat Source: Methane Flame (41 kW/m^2, 925 ºC)

Heat Source Exposure: 12 seconds

Flame Extinguishing Time: <15 seconds

Burn Length: <20.32cm

Drip Extinguishing Time: <5 seconds

Approach

Intermediate-Scale Fire Test:

Test Protocol: FAA Report DOT/FAA/AR-99/44 - Dev. Of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation

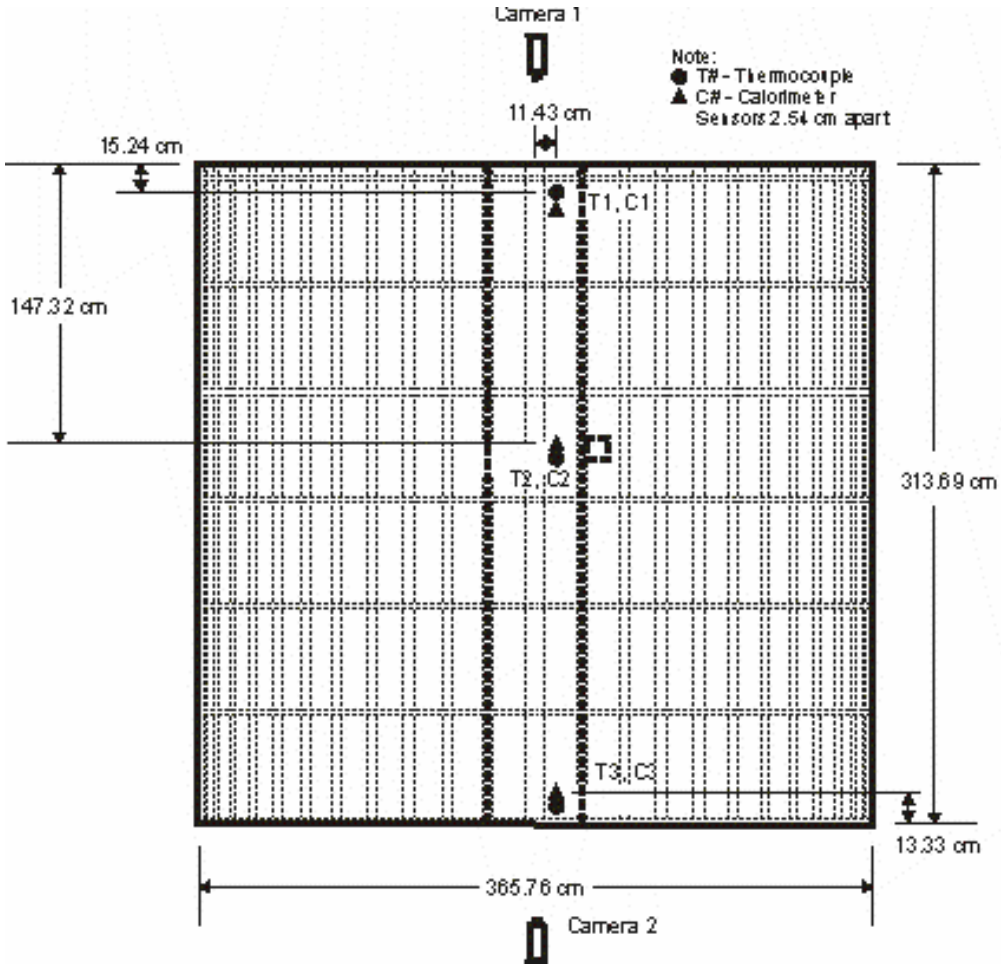
Sample Size: 15.2cm (30.4cm) x 243.8cm

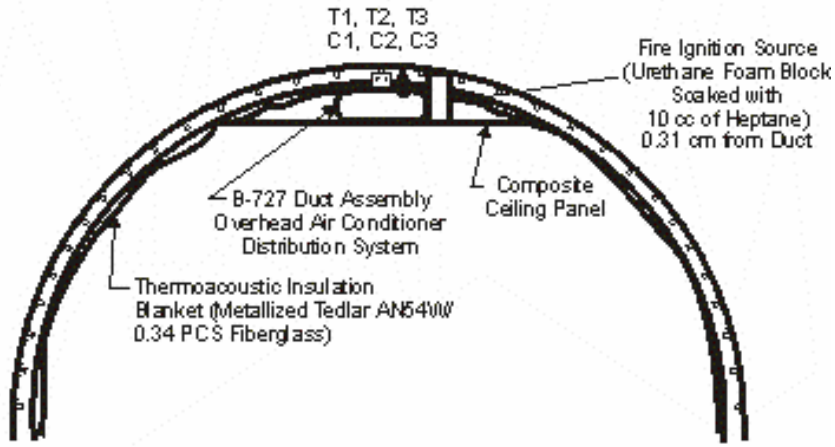
Heat Source: Polyurethane Foam Block (49 kW/m^2, 781 ºC)

Heat Source Exposure: ~10 minutes

Not a compliance test

Approach


Camera 1
Note:
● T# - Thermocouple
▲ C# - Calorimeter
Sensors 2.54 cm apart
11.43 cm
15.24 cm
147.32 cm
T1, C1
T2, C2
T3, C3
313.69 cm
13.33 cm
365.76 cm
Camera 2


T1, T2, T3
C1, C2, C3
Fire Ignition Source
(Urethane Foam Block
Soaked with
10 cc of Heptane)
0.31 cm from Duct
B-727 Duct Assembly
Overhead Air Conditioner
Distribution System
Composite
Ceiling Panel
Thermoacoustic Insulation
Blanket (Metallized Tedlar AN54WW
0.34 PCS Fiberglass)

Approach

Heat Release Rate Test for Cabin Materials:

Test Protocol: Chapter 5 of DOT/FAA/CT-89/15 Aircraft Material Fire Test Handbook

Sample Size: 150mm x 150mm

Heat Source: Methane Flame & Radiant Heating Coils (35 kW/m^2)

Heat Source Exposure: 5 minutes

Max Avg. Heat Release Rate: <65 kW/m^2

Max Avg. Total Heat Released (2 min): <65 kW*min/ m^2

Approach

Smoke Test for Cabin Materials:

Test Protocol: Chapter 6 of DOT/FAA/CT-89/15 Aircraft Material Fire Test Handbook

Sample Size: 73mm x 73mm

Heat Source: Methane Flame & Radiant Heating Coils (25 kW/m^2)

Heat Source Exposure: 4 minutes

Max Avg. Specific Optical Density, Dm: <200

Approach

Micro-scale Combustion Calorimeter Test:

Test Protocol: FAA Report DOT/FAA/AR-01/117 A Microscale Combustion Calorimeter

Sample Size: 1 milligram

Heat Source: Heating Coils (900 ºC)

Heat Source Exposure: 10 to 120 seconds to effect pyrolysis

Not a compliance test

Approach

Radiant Panel Test:

Test Protocol: Appendix F to Part 25 (Part IV) – Test Method To Determine the Flammability and Flame Propagation Characteristics of Thermal/Acoustic Insulation Materials

Sample Size: 318mm x 584mm

Heat Source: Propane Flame & Radiant Heating Coils (17 kW/m^2 panel, 147 kW/m^2 pilot)

Heat Source Exposure: 15 seconds (pilot) and until flames are extinguished (radiant panel)

Max Flame Propagation: < 5.08 cm

Max Flame Time: < 3 seconds

Results

12 Seconds Vertical Bunsen Burner Test:

Results

12 Seconds Vertical Bunsen Burner Test:

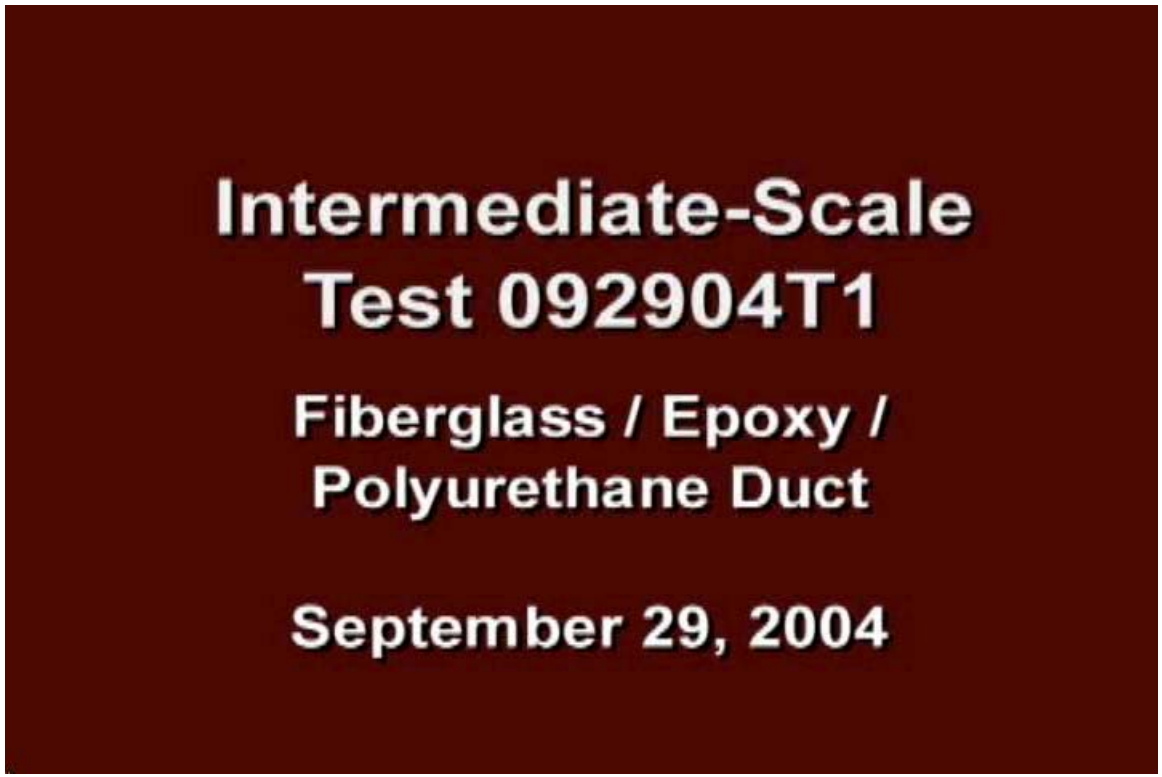
ITEM NO.	MATERIAL	MATERIAL DETAIL INFORMATION	TEST NUMBER	FLAME EXTINGUISHING TIME	BURN LENGTH (CM)	DRIP EXTINGUISHING TIME	COMMENTS	Pass or Fail
1	Fiberglass/Epoxy/Polyurethane	Sample from B727 air conditioner overhead duct (1980)	092104T11	0	6.99	0	Fire damage area = 6.98 cm^2; charring, foam core was involved in fire.	Passed
			092104T12	0	6.99	0	Fire damage area = 6.98 cm^2; charring, foam core was involved in fire.	Passed
			092104T13	8	7.62	0	Fire damage area = 6.98 cm^2; charring, foam core was involved in fire; it spark and had after flames.	Passed

Results

Intermediate-Scale Fire Test (Pretest):

Results

Intermediate-Scale Fire Test:



Results

Intermediate-Scale Fire Test:

2	INTERMEDIATE-SCALE TEST				
	Burn Length (cm)	304.8	304.8		Duct burned completely. Duct length was 304.8 cm.
	Heat Release Peak (kW/m^2)	91	63		Ignition source peak heat flux was 62 kW/m^2 with a total heat release of 43.8 $kW*min/m^2$ in 2 minutes.
	Time to Peak Heat Flux (sec)	63	66		This time is from ignition to heat flux peak.
	Peak Temperature (degC)	825	835		
	Pass or Failed Test?	**Failed**	**Failed**		There is no FAA acceptance criteria for this test; but, it was completely destroyed.

Results

Heat Release Rate Test for Cabin Materials:

3	HEAT RELEASE TEST*				
	Heat Release Peak (kW/m^2)	74.34	87.86	86.23	Heat Flux of OSU was 35.042 kW/m^2. FAR requires that this value does not exceed 65 kW/m^2.
	Heat Release Peak Time (sec)	12	9	8	
	Total Heat Release (kW*min/m2)	105.11	110.83	119.56	FAR requires that this value does not exceed 65 kW*min/m^2.
	Pass or Fail Test?	**Failed**	**Failed**	**Failed**	

Results

Microscale Calorimeter Test:

4	**MICRO-SCALE COMBUSTION CALORIMETER***	Fiberglass/Epoxy Laminate	Polyurethane Foam		
	Heat Release Capacity (J/g-K)	123.0	436.0		There is no FAA acceptance criteria for this test
	Total Heat Release (kJ/g)	13.4	24.7		
	Char (%)	12.6	2.9		

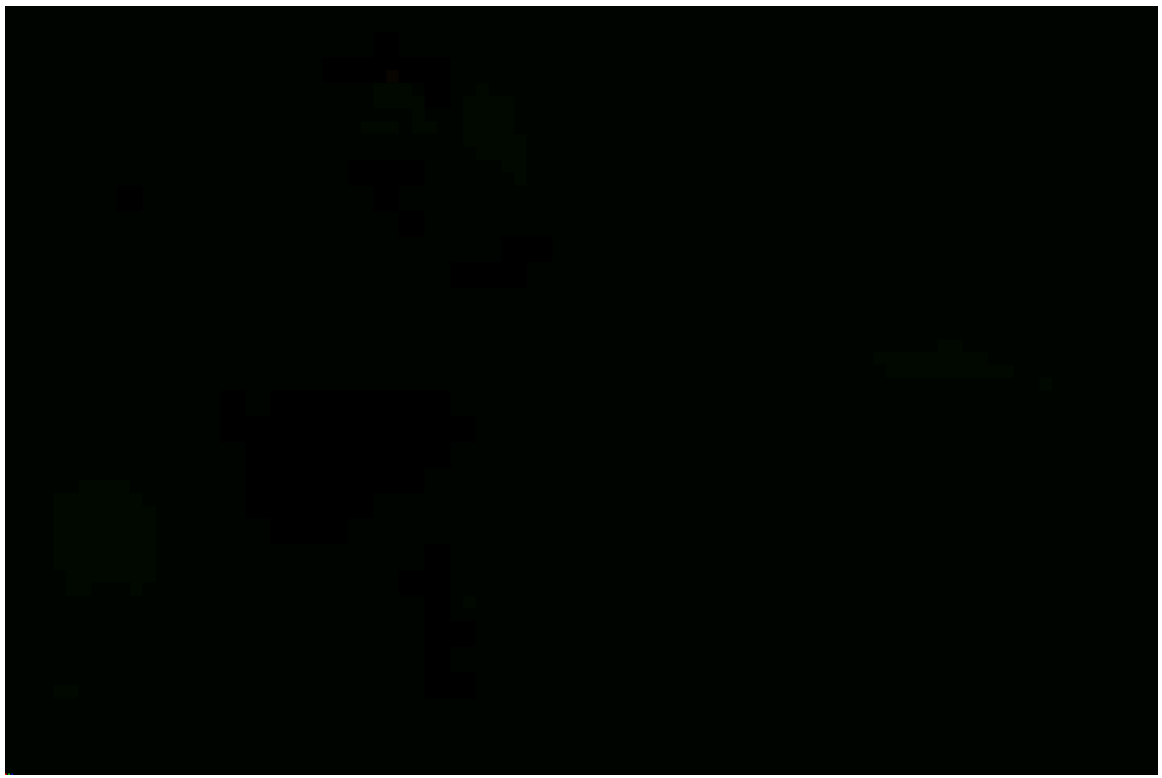
Results

Smoke Test for Cabin Materials:

5	**SMOKE TEST***				
	Maximum Specific Optical Density (D_m)	145.02	119.12	127.94	
	Pass or Fail?	**Passed**	**Passed**	**Passed**	FAR requires that this value does not exceed 200.

Results

Radiant Panel Test:



Results

Radiant Panel Test:

6	**RADIANT PANEL HEAT TEST***				
	Flame Propagation (cm)	Material ignited very fast; test was stopped before end	Material ignited very fast; test was stopped before end	N/A	FAR requires that this value does not exceed 5.08 cm.
	Flame Time (sec)	Material ignited very fast; test was stopped before end	Material ignited very fast; test was stopped before end	N/A	FAR requires that this value does not exceed 3 sec.
	Pass or Fail?	**Failed**	**Failed**	N/A	

Conclusion

• The evaluation test results showed that the currently used method to certify aircraft ducts and conduits, that is the 12-second Vertical Bunsen Burner test, is not robust enough to correctly differentiate between a fireworthy and a non-fireworthy material as expected by today's level of safety.

• The intermediate-scale test, the OSU heat release rate test, and the radiant panel test showed how deficient is the fireworthiness property of the evaluated aircraft material (fiberglass/epoxy/polyurethane composite).

Recommendation

The William J. Hughes FAA Technical Center recommends that a new fire test method be developed and used to certify the materials that fall under that particular federal regulation.

Ongoing Work

Additional aircraft duct materials are currently been tested to characterize their fireworthiness and provide data for the development of a new test for means of compliance with FAR 25.853 (Compartment Interiors).

Material Available for Testing

ITEM NO.	MATERIAL
1	Fibrglass/Epoxy/Polyurethane
2	Fiberglass/Polyester (2 Ply)
3	Fiberglass/Epoxy (2 Ply)
4	Ultem
5	Radel
6	Nylon
7	Kevlar/Epoxy (2,3 4 Ply)
8	Fiberglass/PEI
9	Graphic/PEI
10	Kevlar/PEI (2 & 3 Ply)

Acknowledgement

Many thanks to the following people for their assistance in this program:

Eldon Barr, Triumph Composite Systems

Pat Cahill, FAA

Joseph Canavan, Triumph Composite Systems

Brian Conover, GSC

Sean Crowley, GSC

FAA Video Crew

Frank Gibbons, GSC

Susan Glicksberg, Boeing

Richard Johnson, FAA

Kendall Krieg, Boeing

Doug Maben, Boeing

Barbara Maclean, Boeing

Tim Marker, FAA

Rich Mazzone, Boeing

Jim Peterson, Boeing

Paul Scrofani, GSC

Dan Slaton, Boeing

Rich Walters, GSC

Rick Whedbee, GSC