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
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.
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.
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
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/m², 925 °C)

**Heat Source Exposure:** 12 seconds

**Flame Extinguishing Time:** <15 seconds

**Burn Length:** <20.32cm

**Drip Extinguishing Time:** <5 seconds
Intermediate-Scale Fire Test:


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

**Heat Source:** Polyurethane Foam Block (49 kW/m², 781 °C)

**Heat Source Exposure:** ~10 minutes

**Not a compliance test**
Approach

Camera 1

Note:

- T: Thermocouple
- C: Calorimeter
- S: Sensors 2.5 cm apart

15.24 cm
11.43 cm

147.32 cm

313.69 cm

365.76 cm
13.33 cm

Camera 2

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

Thermoacoustic Insulation
Blanket (Metallized Tedlar AN644WF
0.34 P.C.S. Fiberglass)

Composite Ceiling Panel
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
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/m²)

**Heat Source Exposure:** 4 minutes

**Max Avg. Specific Optical Density, Dm:** <200
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 °C)

**Heat Source Exposure**: 10 to 120 seconds to effect pyrolysis

**Not a compliance test**
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/m² panel, 147 kW/m² 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
12 Seconds Vertical Bunsen Burner Test:
## 12 Seconds Vertical Bunsen Burner Test:

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>MATERIAL</th>
<th>MATERIAL DETAIL INFORMATION</th>
<th>TEST NUMBER</th>
<th>FLAME EXTINGUISHING TIME</th>
<th>BURN LENGTH (CM)</th>
<th>DRIP EXTINGUISHING TIME</th>
<th>COMMENTS</th>
<th>Pass or Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fiberglass/Epoxy/Polyurethane Sample from 737 air conditioner overhead duct (1983)</td>
<td>092104T11</td>
<td>0</td>
<td>6.99</td>
<td>0</td>
<td>Fire damage area = 6.98 cm²; charring, foam core was involved in fire</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>092104T12</td>
<td>0</td>
<td>6.99</td>
<td>0</td>
<td>Fire damage area = 6.98 cm²; charring, foam core was involved in fire</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>092104T13</td>
<td>8</td>
<td>7.62</td>
<td>0</td>
<td>Fire damage area = 6.98 cm²; charring, foam core was involved in fire, it sparked and had after flames</td>
<td>Passed</td>
<td></td>
</tr>
</tbody>
</table>
Intermediate-Scale Fire Test (Pretest):
Intermediate-Scale Fire Test:

Intermediate-Scale Test 092904T1
Fiberglass / Epoxy / Polyurethane Duct
September 29, 2004
## Intermediate-Scale Fire Test:

<table>
<thead>
<tr>
<th></th>
<th>INTERMEDIATE-SCALE TEST</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Burn Length (cm)</td>
<td>304.8</td>
<td>304.8</td>
<td>Duct burned completely. Duct length was 304.8 cm.</td>
</tr>
<tr>
<td></td>
<td>Heat Release Peak (kW/m²)</td>
<td>91</td>
<td>63</td>
<td>Ignition source peak heat flux was 62 kW/m² with a total heat release of 43.6 kW*min/m² in 2 minutes.</td>
</tr>
<tr>
<td></td>
<td>Time to Peak Heat Flux (sec)</td>
<td>63</td>
<td>66</td>
<td>This time is from ignition to heat flux peak.</td>
</tr>
<tr>
<td></td>
<td>Peak Temperature (degC)</td>
<td>625</td>
<td>835</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pass or Failed Test?</td>
<td>Failed</td>
<td>Failed</td>
<td>There is no FAA acceptance criteria for this test; but, it was completely destroyed.</td>
</tr>
</tbody>
</table>
## Heat Release Rate Test for Cabin Materials:

<table>
<thead>
<tr>
<th></th>
<th>HEAT RELEASE TEST*</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat Release Peak (kW/m²)</td>
<td>74.34</td>
<td>57.86</td>
<td>86.23 Heat Flux of OSU was 35.042 kW/m². FAR requires that this value does not exceed 65 kW/m².</td>
</tr>
<tr>
<td></td>
<td>Heat Release Peak Time (sec)</td>
<td>12</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total Heat Release (kW*min/m²)</td>
<td>105.11</td>
<td>110.83</td>
<td>119.56 FAR requires that this value does not exceed 65 kW*min/m².</td>
</tr>
<tr>
<td></td>
<td>Pass or Fail Test?</td>
<td>Failed</td>
<td>Failed</td>
<td>Failed</td>
</tr>
</tbody>
</table>
Microscale Calorimeter Test:

<table>
<thead>
<tr>
<th></th>
<th>MICRO-SCALE COMBUSTION CALORIMETER*</th>
<th>Fiberglass/Epoxy Laminate</th>
<th>Polyurethane Foam</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Heat Release Capacity (J/g-K)</td>
<td>123.0</td>
<td>436.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Heat Release (kJ/g)</td>
<td>13.4</td>
<td>24.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Char (%)</td>
<td>12.6</td>
<td>2.9</td>
<td></td>
</tr>
</tbody>
</table>

There is no FAA acceptance criteria for this test.
## 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. |
Radiant Panel Test:
## Radiant Panel Test:

<table>
<thead>
<tr>
<th></th>
<th>RADIANT PANEL HEAT TEST*</th>
<th>Flame Propagation (cm)</th>
<th>Flame Time (sec)</th>
<th>Pass or Fail?</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td></td>
<td>Material ignited very fast; test was stopped before end</td>
<td>Material ignited very fast; test was stopped before end</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FAR requires that this value does not exceed 5.08 cm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAR requires that this value does not exceed 3 sec.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>N/A</th>
</tr>
</thead>
</table>

* RADIANT PANEL HEAT TEST refers to a test conducted on radiant panels to assess their fire resistance properties.
• 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).
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.
Additional aircraft duct materials are currently being 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

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fiberglass/Epoxy/Polyurethane</td>
</tr>
<tr>
<td>2</td>
<td>Fiberglass/Polyester (2 Ply)</td>
</tr>
<tr>
<td>3</td>
<td>Fiberglass/Epoxy (2 Ply)</td>
</tr>
<tr>
<td>4</td>
<td>Ultem</td>
</tr>
<tr>
<td>5</td>
<td>Radel</td>
</tr>
<tr>
<td>6</td>
<td>Nylon</td>
</tr>
<tr>
<td>7</td>
<td>Kevlar/Epoxy (2,3,4 Ply)</td>
</tr>
<tr>
<td>8</td>
<td>Fiberglass/PEI</td>
</tr>
<tr>
<td>9</td>
<td>Graphic/PEI</td>
</tr>
<tr>
<td>10</td>
<td>Kevlar/PEI (2 &amp; 3 Ply)</td>
</tr>
</tbody>
</table>
Many thanks to the following people for their assistance in this program:

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