Development of an Improved Fire Test Method and Criteria for Aircraft Electrical Wiring

PROJECT STATUS

Presented to: International Aircraft Materials Fire Test Working Group

By: John Reinhardt, Project Manager, PMP

Date: October 21, 2008

Location: Atlantic City, NJ
AGENDA

• Project Charter
• Scope Statement
• Work Breakdown Structure
  – Material Testing
  – Evaluate Test Methods
  – Select/Modify Evaluated Test Method
• Final Words
Initiating Process

PROJECT CHARTER

• Objectives:
  ✓ Develop a fire test method for aircraft electrical wiring that could adequately discriminate between poorly performing wire insulation materials and fire worthy ones when exposed to a realistic fire scenario.

• Requirements:
  ✓ Submit a final report documenting the developmental project and the new test method.

• Due Date (milestone):
  ✓ 30 June 2009: Draft Final Report
SCOPE STATEMENT

• This project will focus on the flammability characteristics of aircraft wiring insulation only.

• It will consider the Radiant Heat Panel test apparatus as a candidate replacement.

• Excluded: wire arcing, design issues, installation issues, maintenance issues, FAA policies, etc.
Planning Process: Scope

Work Breakdown Structure

1. NEW FLAMMABILITY TEST FOR AIRCRAFT WIRING

1.1 Review Historical Information
1.2 Meet with Stakeholders
1.3 Define Fire Threat
1.4 Test Methods Selection
1.5 Material Selection

1.6 Material Testing
1.7 Evaluate Test Methods
1.8 Select/Modify Evaluated Test Method
1.9 Verify Test Method
1.10 Publish Test Method

✓ Completed
➢ In Progress
Execution Process: WBS 1.6

WBS 1.6 Material Testing

Tests to be conducted:

- 60-Degree Bunsen Burner Test
- Micro-Scale Combustion Calorimeter
  - Intermediate-Scale Fire Test
## Development of an Improved Fire Test Method and Criteria for Aircraft Electrical Wiring

### Execution Process: WBS 1.6

<table>
<thead>
<tr>
<th>Wire Specification</th>
<th>Intermediate Scale Test</th>
<th>60 Degree Test</th>
<th>MSCC Test</th>
<th>RHP Test</th>
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Execution Process: WBS 1.6

WBS 1.6 Material Testing

• 60-DEGREE BUNSEN BURNER TEST FOR ELECTRIC WIRE
  – Test Protocol: Chapter 4 of DOT/FAA/AR-00/12 “Aircraft Materials Fire Test Handbook”
  – Sample Size: 76.2 cm (mark: 20.3 cm); mounted at 60 degrees from horizon
  – Heat Source: Methane Flame (T>954°C), perpendicular to wire sample
  – Heat Source Exposure: 30 sec
  – Flame Extinguishing Time: <30 sec
  – Burn Length: <7.6 cm
  – Drip Extinguishing Time: <3 sec
FAA 60-DEGREE BUNSEN BURNER TEST FOR ELECTRIC WIRE

**Requirements:** Average Extinguishing Time \(\leq 30\) seconds, Average Burn Length \(\leq 7.6\) cm

- Mil-17/28-RG58
- Hypalon
- Riser Cable CAT5e
- Riser Cable CAT3
- Belden 9804 Cable (PVC-PP)
- MS81044/6 (XL-PA)
- Fiber Optic M9B037 (PVC)
- MS22759/33 (XL-ETF
E)
- MS22759/16 (ETF
E)
- BMS13-48 (EX-XL-ETFE)
- BMS13-55 (PTFE)
- MS22759/5 (TFE)
- MS22759/14 (FEP-PVF
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- MS22759/32 (Z-XL-M-ETFE)
- MS22759/11 (TFE)
- BMS13-72 (FEP-PTFE)
- MS81381/21 (PI)
- BMS13-60 (PTFE-PI)
- MS22759/86 (FP-PI)

Note: All wire samples had zero second drip extinguishing time

MS5086/1 (PVC/Nylon)

Radix Silicone 200
Execution Process: WBS 1.6

Wire Sample: MIL-17/28-RG58 (B.L. = 5.6 cm, FET = 3 sec)
Execution Process: WBS 1.6

WBS 1.6 Material Testing

- **MICRO-SCALE COMBUSTION CALORIMETER TEST**
  - **Test Protocol:** FAA Report DOT/FAA/AR-01/117 “A Micro-scale Combustion Calorimeter”
  - **Sample Size:** milligram range
  - **Heat Source:** Heating Coils (ramps up from 21 to 900 °C)
  - **Heat Source Exposure:** 1°C per sec to effect pyrolysis
  - **Not a compliance test**
Execution Process: WBS 1.6

Micro-Scale Combustion Calorimeter Fireworthy Box (From Ducting Tests)
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Federal Aviation Administration

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Development of an Improved Fire Test Method and Criteria for Aircraft Electrical Wiring

Federal Aviation Administration

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Execution Process: WBS 1.6

**WBS 1.6 Material Testing**

- **INTERMEDIATE-SCALE FIRE TEST**
  - **Sample Size:** bundle of wire, 1.27 cm in diameter, 304.8 cm long
  - **Heat Source:** Polyurethane Foam Block + 10 cc of Heptane (Avg HF = 77 kW/m2, and Avg T = 810 ºC)
  - **Heat Source Exposure:** ~8 minutes; peak occurrence ~ 1min
  - **Test Duration:** 16 minutes
  - **Not a compliance test**
Development of an Improved Fire Test Method and Criteria for Aircraft Electrical Wiring

Federal Aviation Administration
Execution Process: WBS 1.6

Wire Sample: BMS13-60 (B.L. = 29.5 cm, FET = 1.33 min)
Wire Sample: MS81044/6 (B.L. = 25.7 cm, FET = 1.83 min)
Wire Sample: MIL-17/28-RG58 (B.L. = 109.8 cm, FET = 17.9 min, dripped)
Planning Process: Scope

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- 1.9 Verify Test Method
- 1.10 Publish Test Method

✓ Completed
➢ In Progress
WBS 1.7 EVALUATE TEST METHODS

- Standard tests to be evaluated:
  - Radiant Panel Test (FAR 25.856)
    → Used for aircraft thermo/acoustic insulation
    → Modified version was proven acceptable to test aircraft ducting
    → Acceptance Criteria:
      Fire Propagation
      After Flame Extinguishing Time
      Parallel (Homogeneous) Heat Flux
      Gradient Heat Flux
Parallel (Homogeneous) Heat Flux - The Radiant Heat Panel components were evaluated to determine:

- if the heat across the face of the radiant panel was consistent
- at what distance from the radiant panel, parallel to it, the temperature is 256°C (RHP may be calibrated at 11.3 kW/m² or 17 kW/m²).
- if the pilot flame will reach the specimen wire (when wire is setup parallel to radiant panel)
- the pilot impingement time
RADIANT HEAT PANEL CHARACTERIZATION TESTS
Temperatures Across Panel (@ 19 cm Parallel)

Average Temp (last 10 minutes) = 175 degC
Standard Deviation = 2.35 degC (1.3%)
Execution Process: WBS 1.7

WBS 1.7 EVALUATE TEST METHODS (CONT.)

- Determined distance from panel and impingement time:
  - The distance of 15.24 cm (or 6") was measured to achieve 256°C at the wire when the RHP was calibrated at 17 kW/m²
  - The pilot reached the wire as it swiveled down (tip of blue flame)
  - Ran 2 tests at 30 seconds impingement
    Result: 20 AWG wire broke
  - Ran 6 tests at 15 seconds impingement
    Result: 20 AWG did not break during test
WBS 1.7 EVALUATE TEST METHODS (CONT.)

- **Parallel Heat Flux Test** –
  - Combine FAA 60 Degree wire test with Radiant Heat Panel test
  - Wire parallel to radiant heat panel (30 degrees)
  - Calibrate RHP to 17 kW/m² (1.5 BTU/ft² sec)
  - Place the wire 15.2 cm (6”) away from the radiant heat panel
  - Pre-heat wire for 1 minute @ 256 °C
  - Pilot impingement time for 15 seconds
Execution Process: WBS 1.7

WBS 1.7 EVALUATE TEST METHODS (CONT.)

• **Gradient Heat Flux Test** – This test will be conducted if the Parallel Heat Flux test is not successful.
  
  – Wire test specimens as “Flat Sheets”
  – RHP calibrated at 11.3 kW/m² (1 BTU/ft² seconds).
  – One minute pre-heat
  – The pilot impingement time: 15 seconds
Planning Process: Scope

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- Completed
- In Progress
WBS 1.8 Select/Modify Evaluated Test Method

Step 1

Step 2

Step 3

Patent Pending
### Wire Specification

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Development of an Improved Fire Test Method and Criteria for Aircraft Electrical Wiring
Execution Process: WBS 1.8

Wire Sample: BMS13-60 (B.L. = 2 cm, FET = 0 sec)
Execution Process: WBS 1.8

Wire Sample: MS81044/6 (B.L. = 2.5 cm, FET = 2 sec)
Execution Process: WBS 1.8

Wire Sample: Mil-17/28-RG58 (B.L. = >15 cm, FET = >60 sec)
Final Words

OBSERVATIONS:

• The results obtained in the ISF tests confirms that the FAA 60 Degree Flammability Test is not a good discriminator.

• The MSCC provided useful information about the flammability properties of the wires insulation.

• The Parallel Heat Flux Test method (30 Degrees Radiant Heat Panel Test) looks promising.
## OBSERVATIONS:

<table>
<thead>
<tr>
<th>Wire/Cable ID</th>
<th>FAA 60 Degree Flammability Test</th>
<th>Intermediate-Scale Test</th>
<th>30 Degree Radiant Heat Panel Test</th>
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Final Words
**Final Words**

**WHAT’S NEXT:**

- The FAA will continue testing the remaining 19 insulation specimens using the 30 Degrees RHP test method (Parallel method)
- If results are not successful, proceed with the Gradient Heat Flux test method
Final Words

PROJECT STATUS:

Project Tasks % Completion = 68%
Cost Performance Index = 1.05
Schedule Performance Index = 0.98
Final Words

Questions?