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

Federal Aviation Administration

Outline

AGENDA

- Project Charter
- Scope Statement
- Work Breakdown Structure
  - Material Testing
  - Evaluate Test Methods
  - Select/Modify Evaluated Test Method
- Final Words

Initiating Process

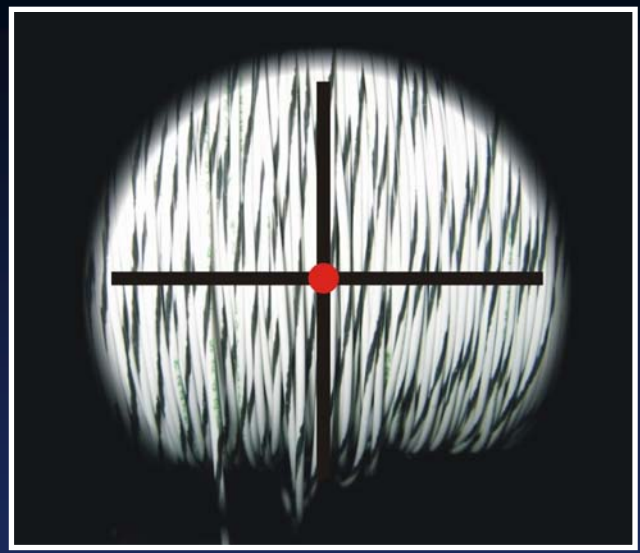
PROJECT CHARTER

- 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

Initiating Process

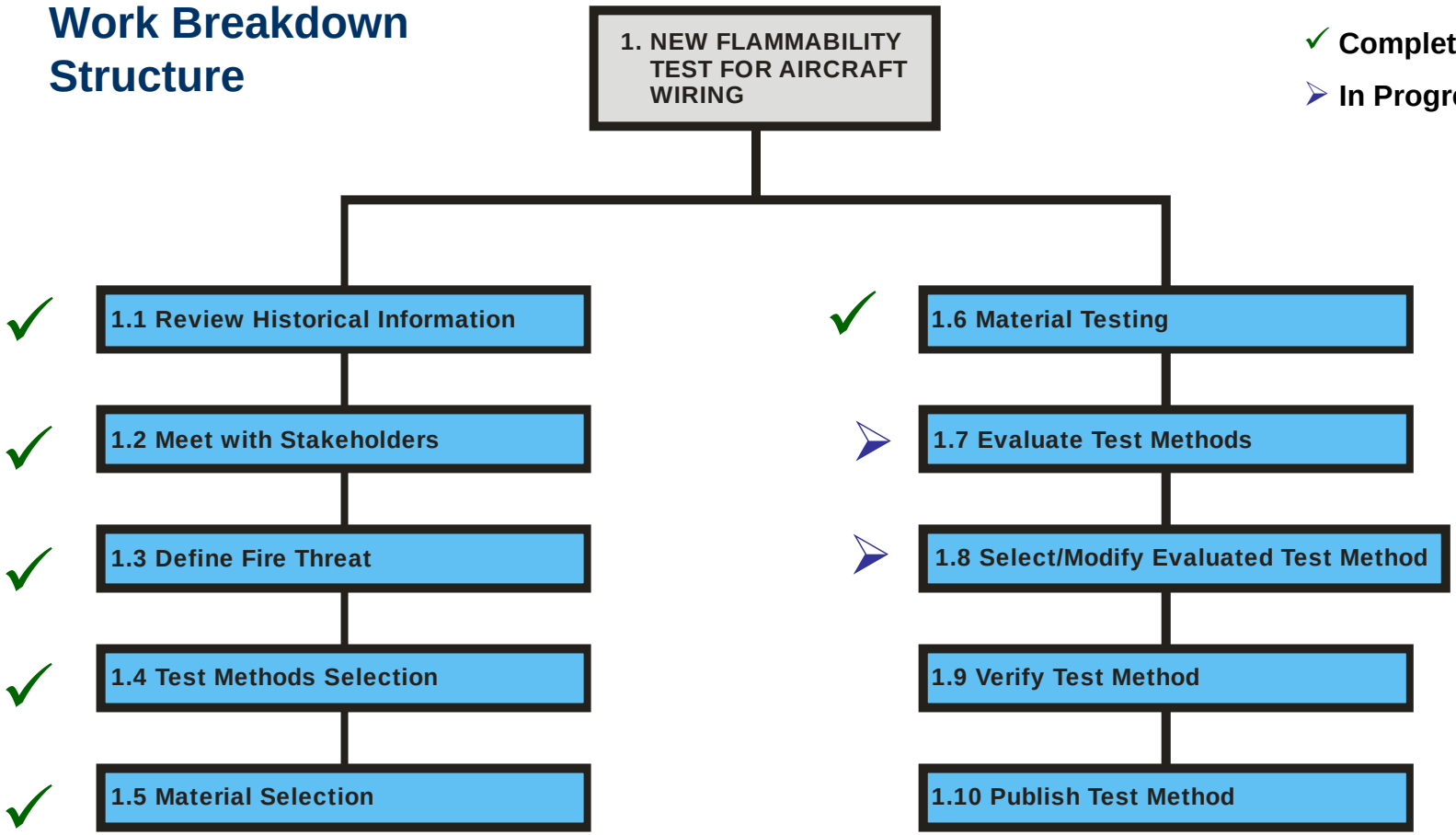
SCOPE STATEMENT

- 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



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

Execution Process: WBS 1.6

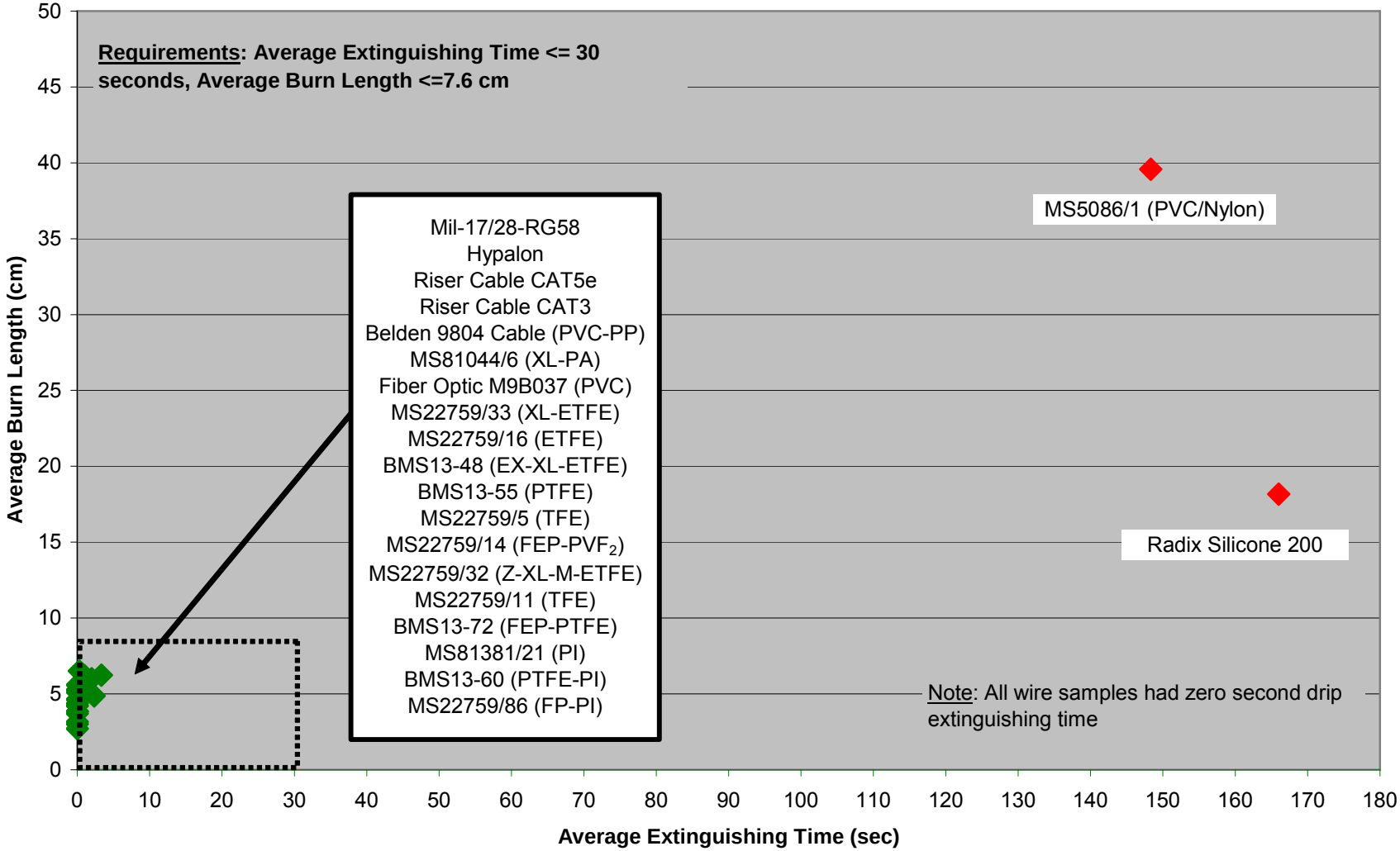
Wire Specification	Intermediate Scale Test	60 Degree Test	MSCC Test	RHP Test
Baseline	X	N/A	N/A	Oct-08
Belden 9804 Cable(PVC-PP)	X	X	X	Oct-08
BMS13-48 (Ex-XL-ETFE)	X	X	X	Oct-08
BMS13-55 (PTFE)	X	X	X	Oct-08
BMS13-60 (PTFE-PI)	X	X	X	Oct-08
BMS13-72 (FEP-PTFE)	X	X	X	Oct-08
Braidless Silicone 200 Lead Wire	X	X	X	Oct-08
Fiber Optic Cable M9B037 (PVC)	X	X	X	Oct-08
Hitachi Riser Cable Cat 3 (FR-PVC)	X	X	X	Oct-08
Hitachi Riser Cable Cat 5e: (FR-PO)	X	X	X	Oct-08
Hypalon Hook-up Wire	X	X	X	Oct-08
M17/28-RG58 (PVC-PE)	X	X	X	Oct-08
MS 22759/16 (ETFE)	X	X	X	Oct-08
MS 22759/32 (Z-XL-M-ETFE)	X	X	X	Oct-08
MS 5086/1 (Nylon-PVC)	X	X	X	Oct-08
MS 81044/6 (XL-PA)	X	X	X	Oct-08
MS 81381/21 (PI)	X	X	X	Oct-08
Neoprene Hook-up Wire	X	X	X	Oct-08
SAE AS 22759/11 (TFE)	X	X	X	Oct-08
SAE AS 22759/14 (FEP-PVF_2)	X	X	X	Oct-08
SAE AS 22759/5 (Ar-TFE)	X	X	X	Oct-08
SAE AS22729 (FP-PI)	X	X	X	Oct-08
SAE AS22759/33 (XL-ETFE)	X	X	X	Oct-08

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>954C), 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



Execution Process: WBS 1.6

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

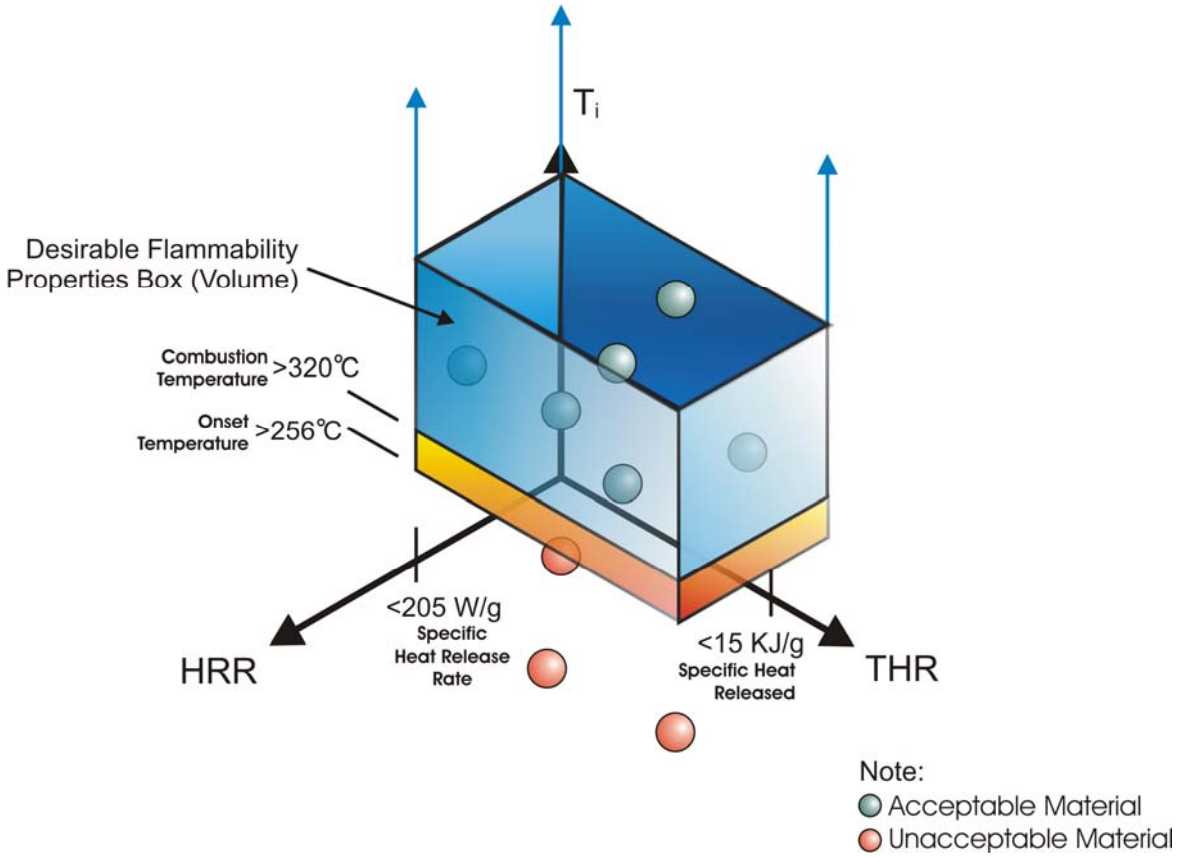
Execution Process: WBS 1.6

WBS 1.6 Material Testing

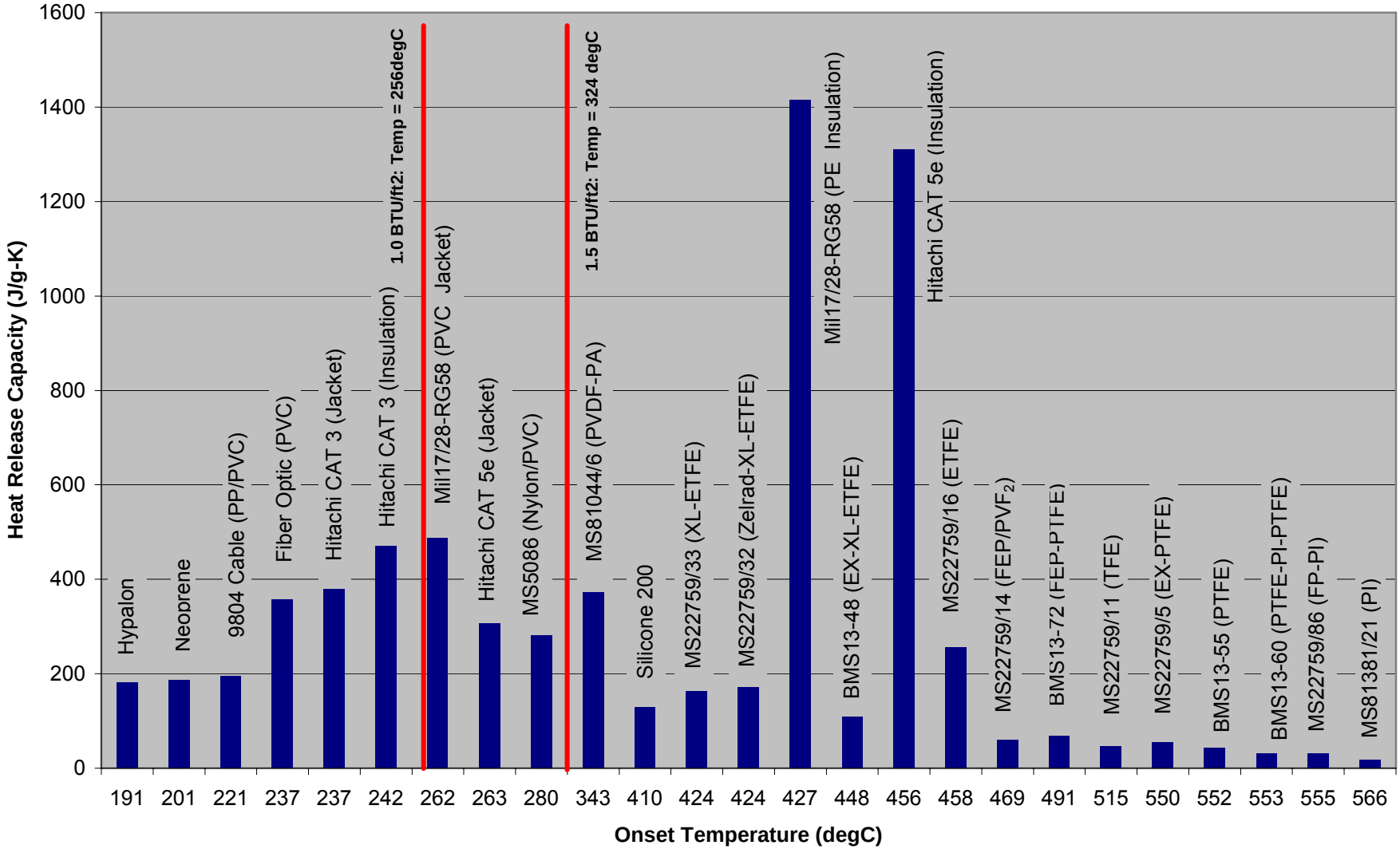
- **MICRO-SCALE COMBUSTION CALORIMETER TEST**
  - **Test Protocol:** FAA Report DOT/FAA/AR-01/117 “A Micro-scale Combustion Calorimeter”
  - **Sample Size:** milligram range
  - **Heat Source:** Heating Coils (ramps up from 21 to 900 ºC)
  - **Heat Source Exposure:** 1ºC per sec to effect pyrolysis
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

Execution Process: WBS 1.6

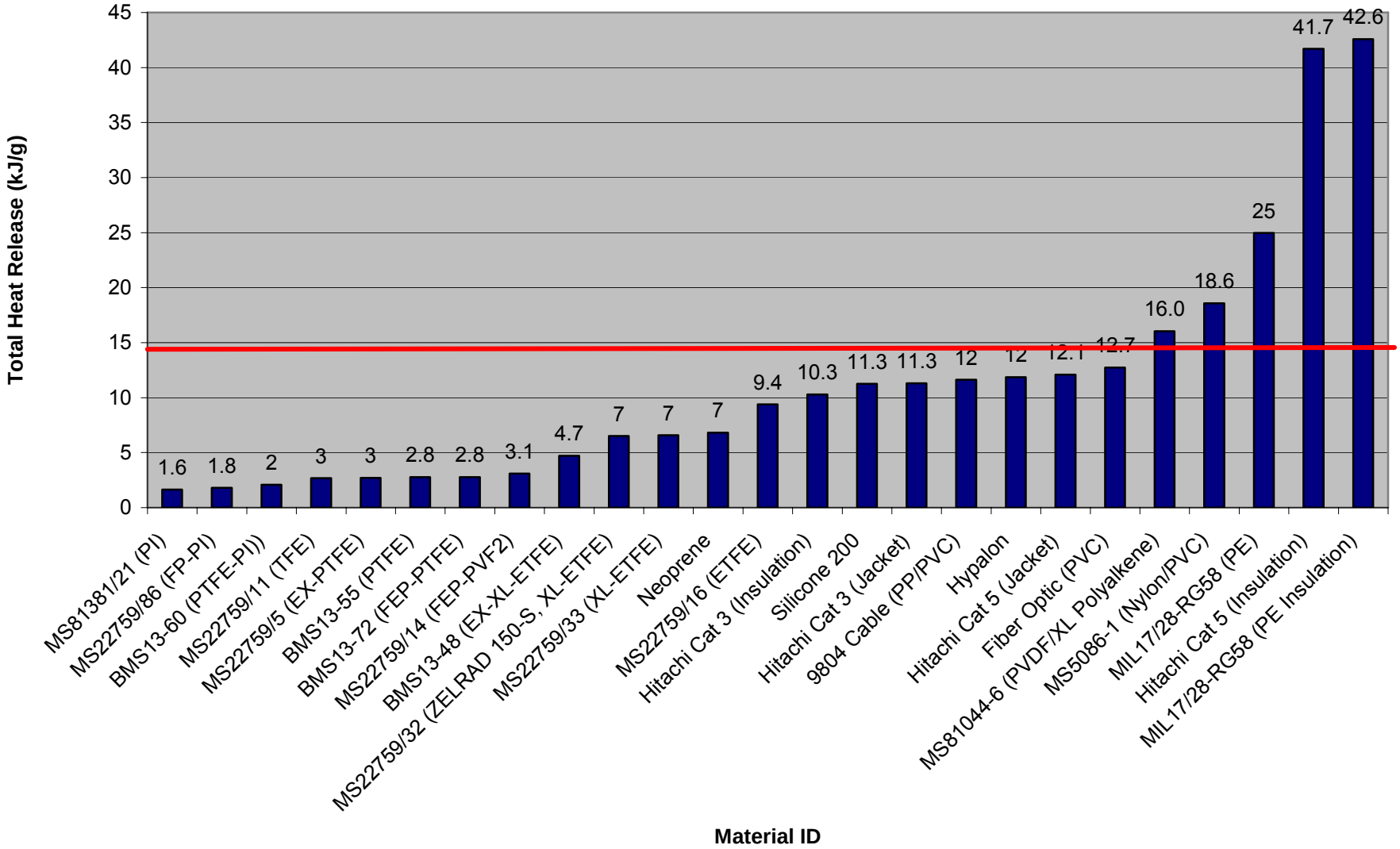
Micro-Scale Combustion Calorimeter Fireworthy Box (From Ducting Tests)



MICRO-SCALE COMBUSTION CALORIMETER TEST OF WIRES/CABLES



MICRO-SCALE COMBUSTION CALORIMETER TEST OF WIRES/CABLES

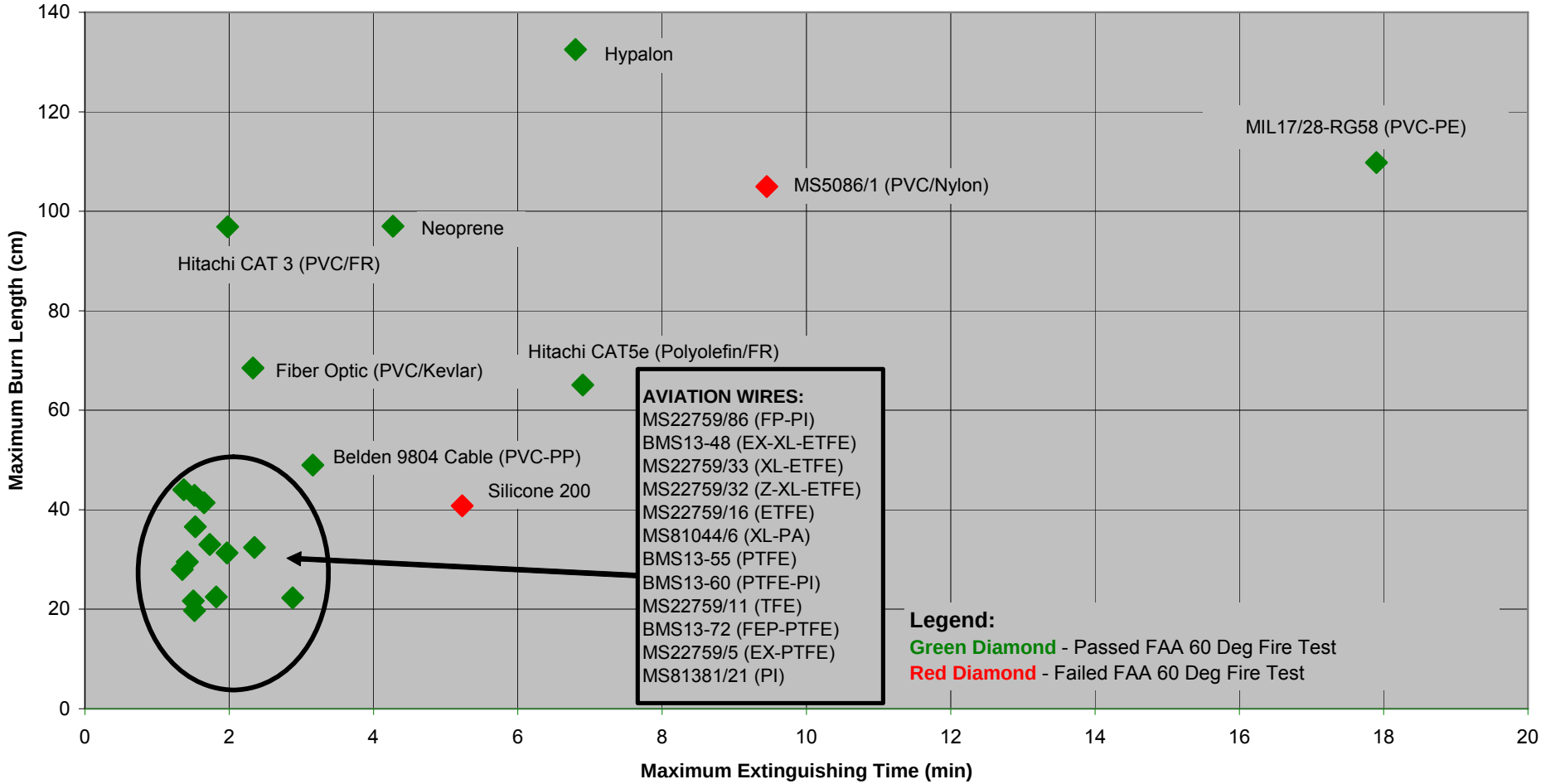


Execution Process: WBS 1.6

WBS 1.6 Material Testing

- **INTERMEDIATE-SCALE FIRE TEST**
  - **Test Protocol:** FAA Report DOT/FAA/AR-08/4 – "Development of an Improved Fire Test Method for Aircraft Ducting," February 2008
  - **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**

INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES



Execution Process: WBS 1.6

Wire Sample: BMS13-60 (B.L. = 29.5 cm, FET = 1.33 min)

Execution Process: WBS 1.6

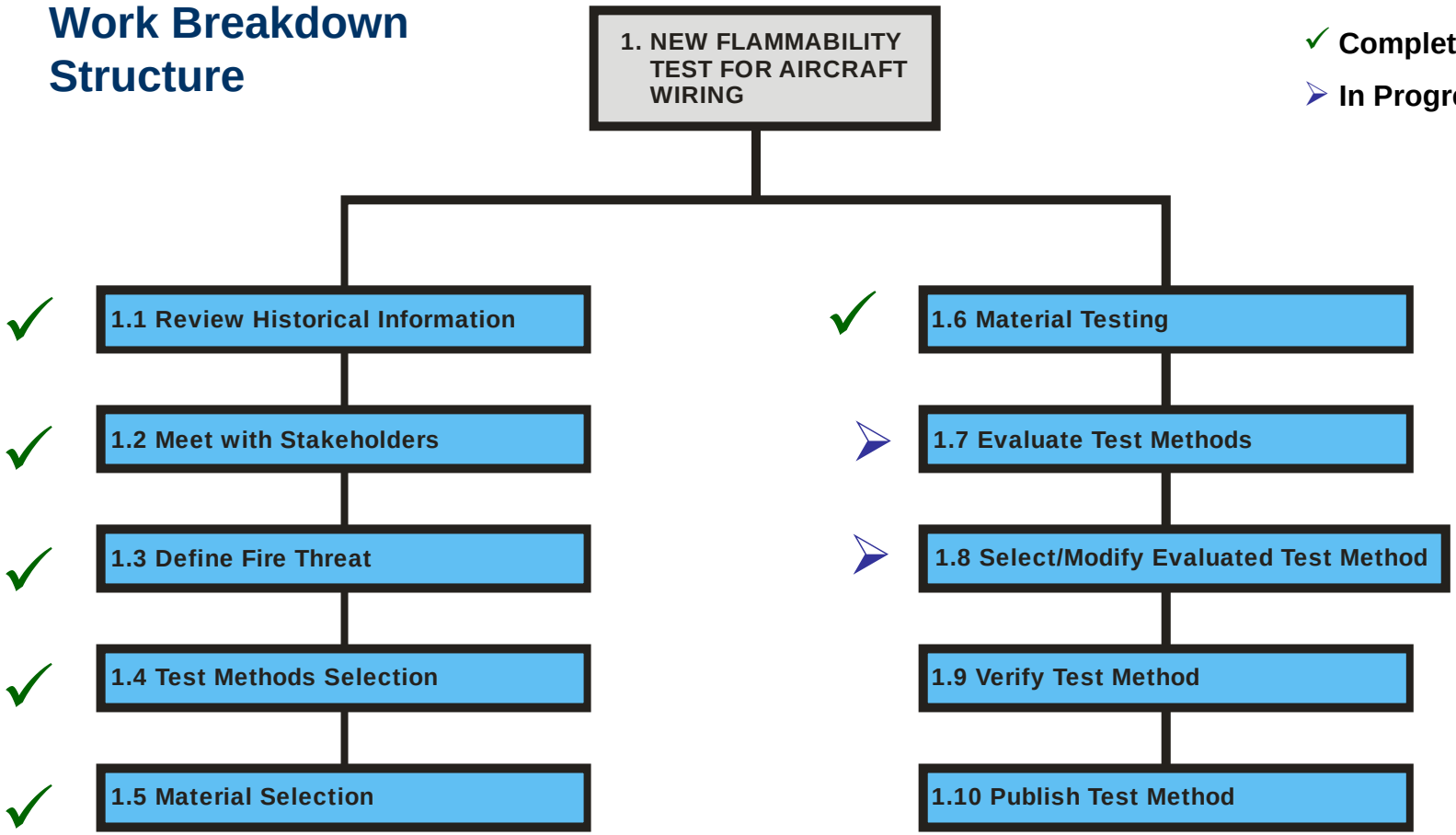
Wire Sample: MS81044/6 (B.L. = 25.7 cm, FET = 1.83 min)

Execution Process: WBS 1.6

Wire Sample: MIL-17/28-RG58 (B.L. = 109.8 cm, FET = 17.9 min, dripped)

Planning Process: Scope

Work Breakdown Structure



Execution Process: WBS 1.7

WBS 1.7 EVALUATE TEST METHODS

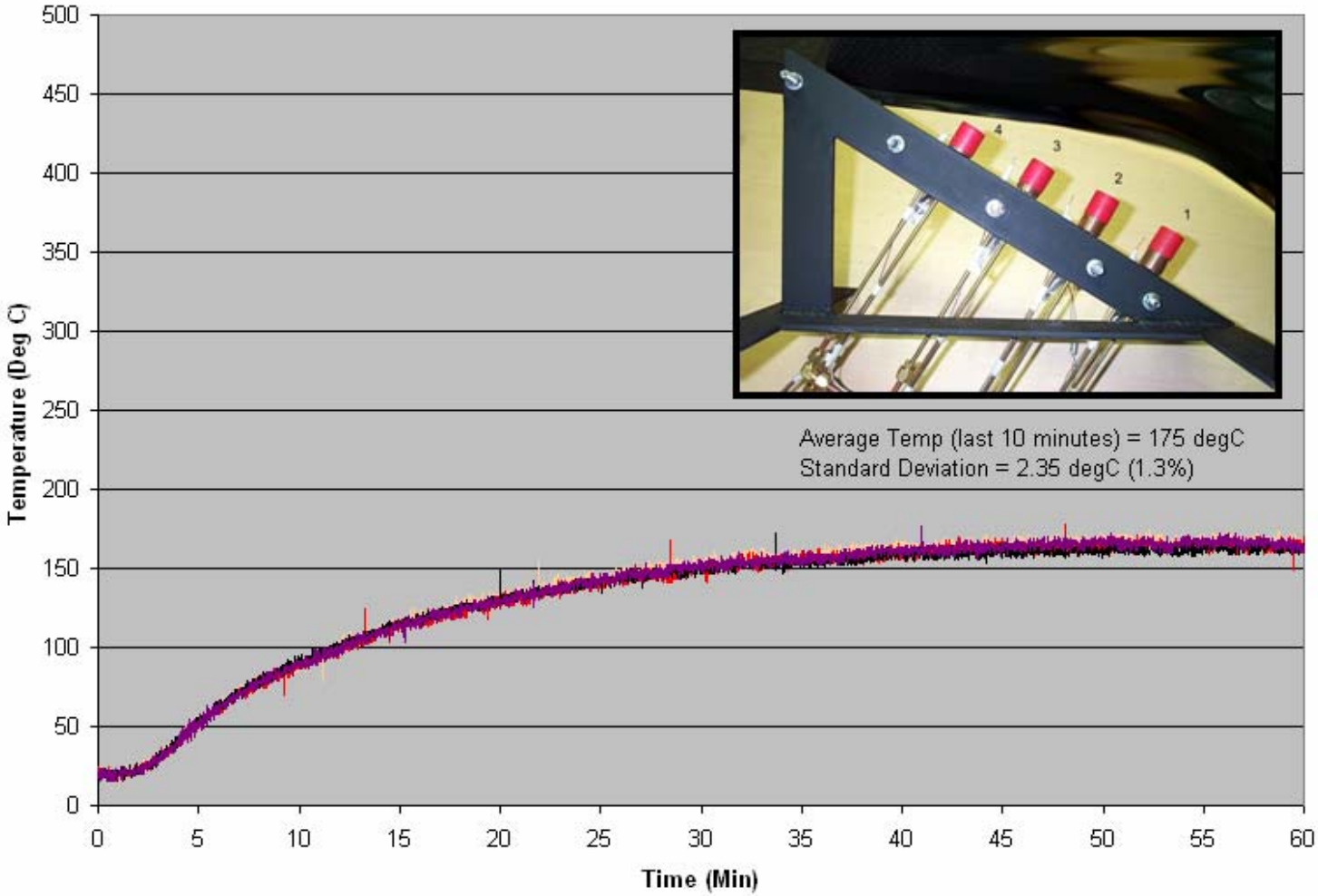
- Standard tests to be evaluated:
  - Radiant Panel Test (FAR 25.856)
    - → Used for aircraft thermo/acoustic insulation
    - → Modified version was proven acceptable to test aircraft ducting
    - → Acceptance Criteria:
      - Fire Propagation
      - After Flame Extinguishing Time
    - → Parallel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

Execution Process: WBS 1.7

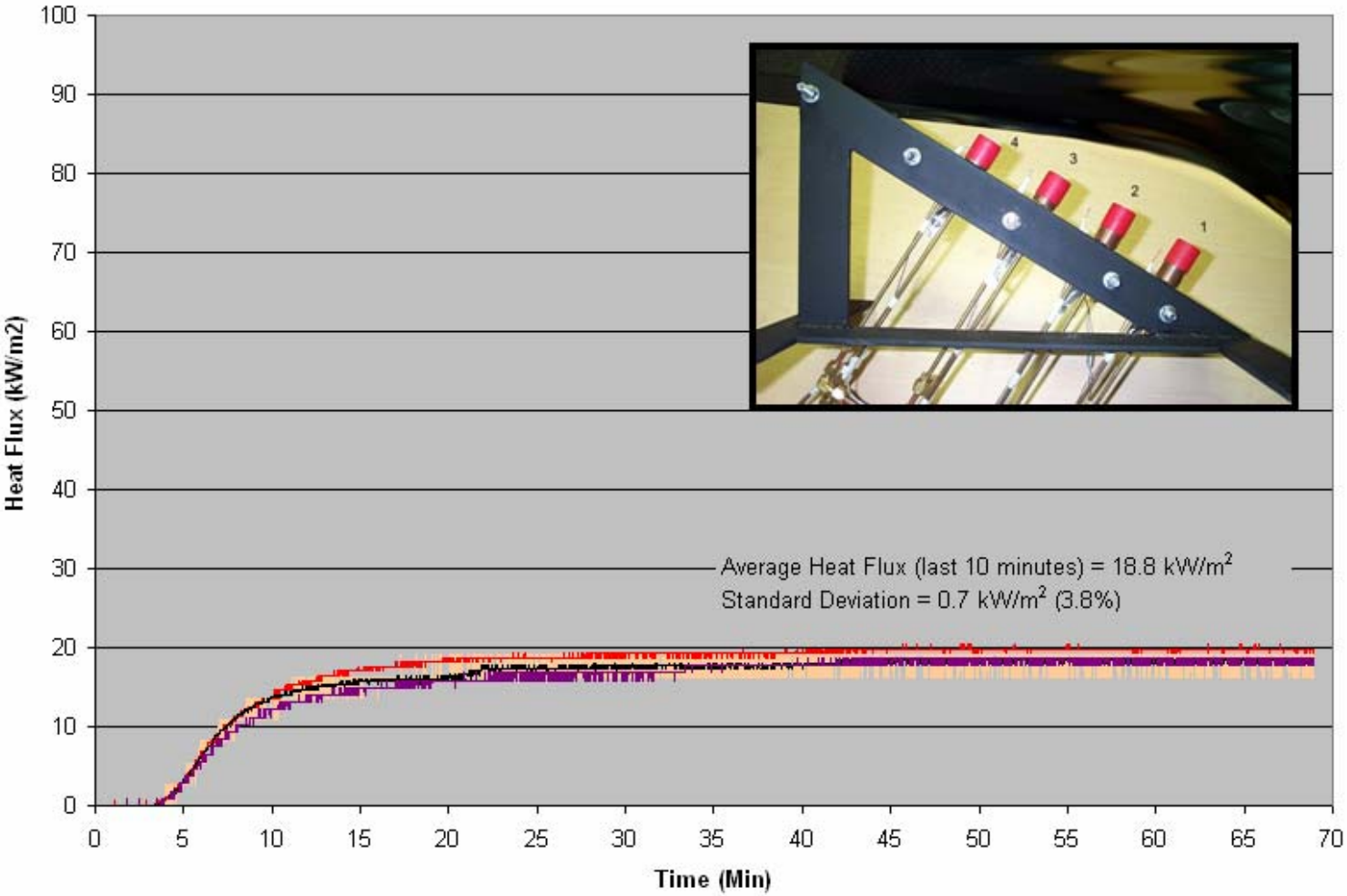
WBS 1.7 EVALUATE TEST METHODS (CONT.)

- 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/m^2 or 17 kW/m^2).
  - – 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)



RADIANT HEAT PANEL CHARACTERIZATION TESTS
Temperatures Across Panel (@ 19 cm Parallel)



Execution Process: WBS 1.7

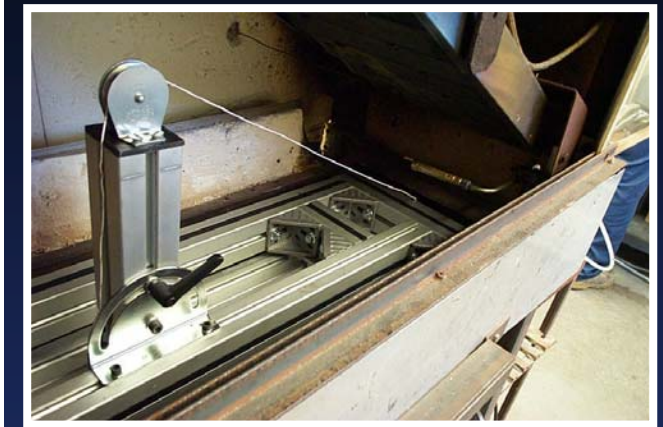
WBS 1.7 EVALUATE TEST METHODS (CONT.)

- **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/m^2
  - 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

Execution Process: WBS 1.7

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



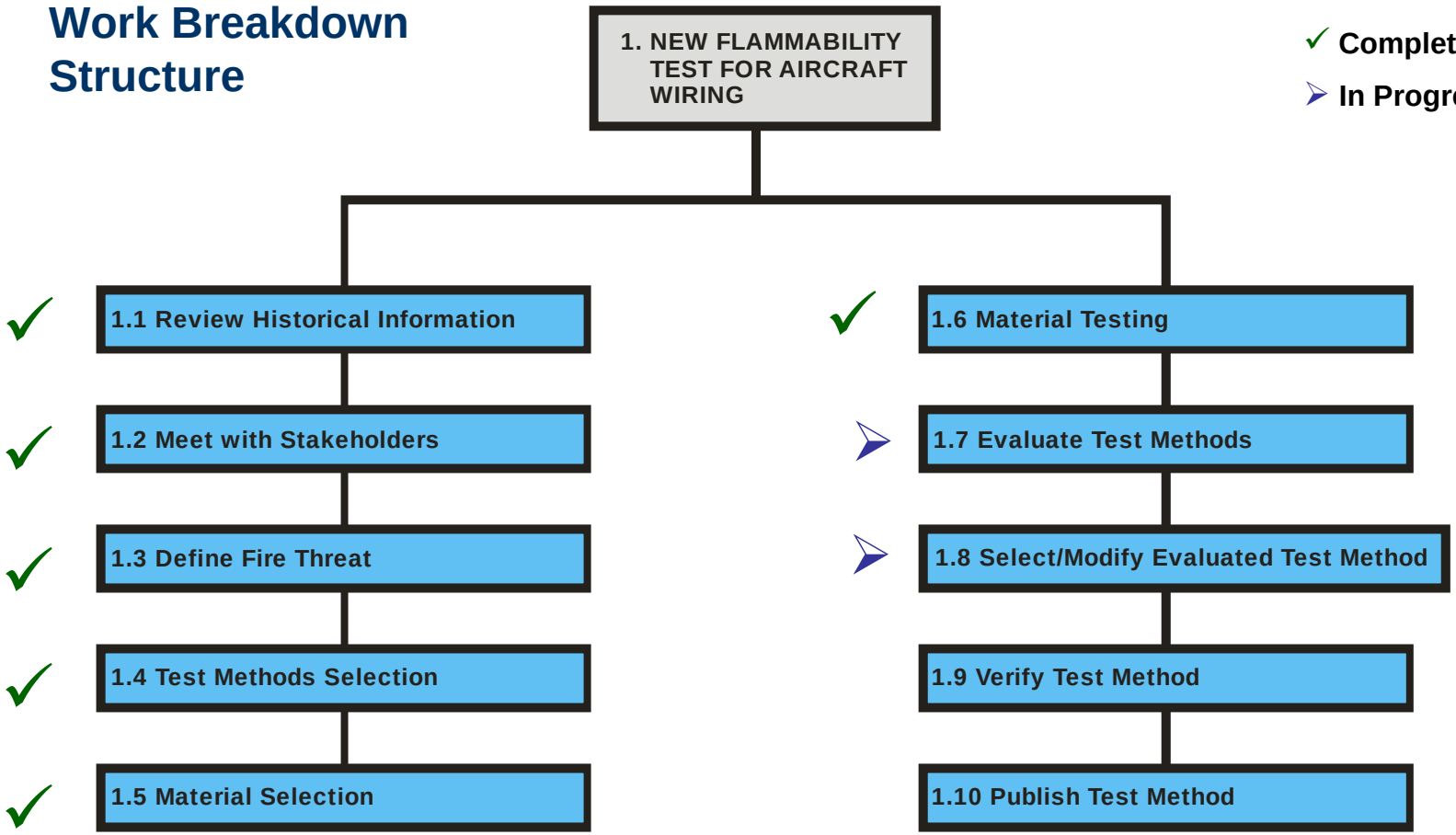
Execution Process: WBS 1.7

WBS 1.7 EVALUATE TEST METHODS (CONT.)

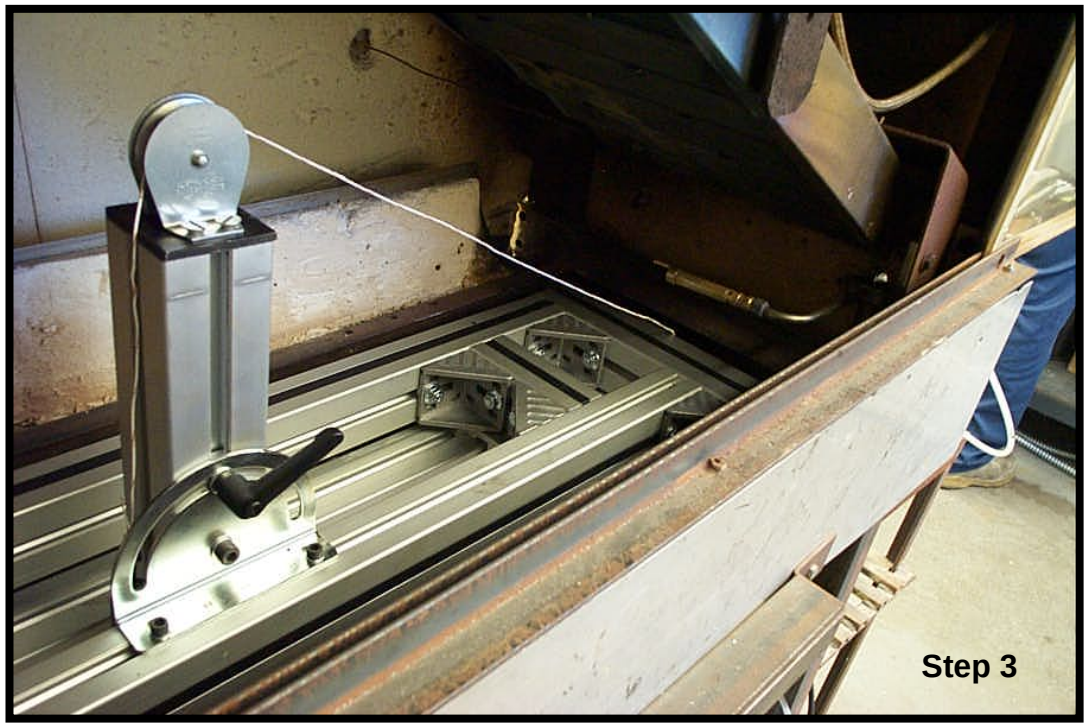
- Gradient Heat Flux Test – This test will be conducted if the Parallel Heat Flux test is not successful.
  - – Wire test specimens as “Flat Sheets”
  - – RHP calibrated at 11.3 kW/m^2 (1 BTU/ft2 seconds).
  - – One minute pre-heat
  - – The pilot impingement time: 15 seconds

Planning Process: Scope

Work Breakdown Structure



WBS 1.8 Select/Modify Evaluated Test Method

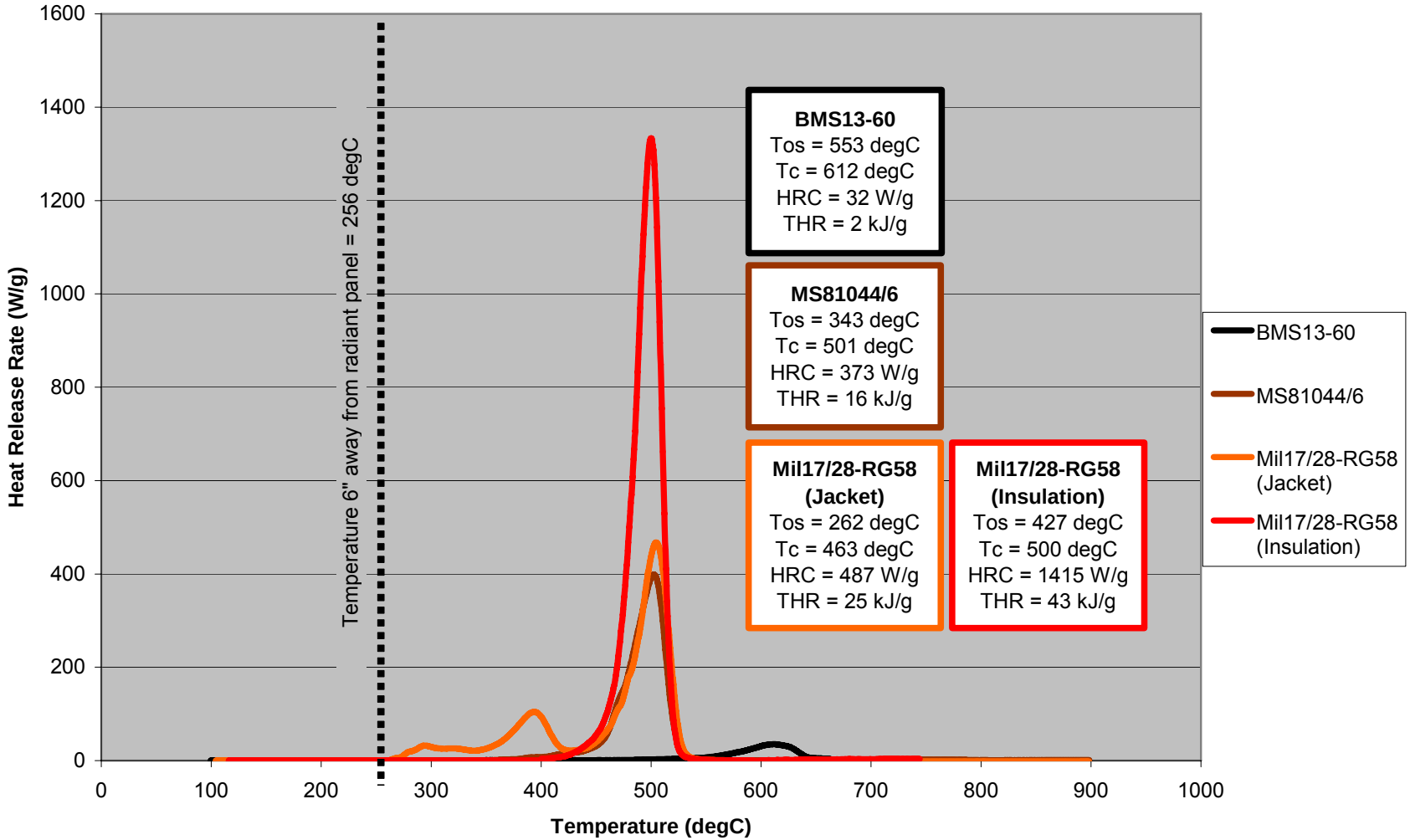


Patent Pending

Execution Process: WBS 1.8

Wire Specification	RHP Test (Version 1)
Baseline	
Belden 9804 Cable(PVC-PP)	
BMS13-48 (Ex-XL-ETFE)	
BMS13-55 (PTFE)	
BMS13-60 (PTFE-PI)	X
BMS13-72 (FEP-PTFE)	
Braidless Silicone 200 Lead Wire	
Fiber Optic Cable M9B037 (PVC)	
Hitachi Riser Cable Cat 3 (FR-PVC)	
Hitachi Riser Cable Cat 5e: (FR-PO)	
Hypalon Hook-up Wire	
M17/28-RG58 (PVC-PE)	X
MS 22759/16 (ETFE)	
MS 22759/32 (Z-XL-M-ETFE)	
MS 5086/1 (Nylon-PVC)	
MS 81044/6 (XL-PA)	X
MS 81381/21 (PI)	
Neoprene Hook-up Wire	
SAE AS 22759/11 (TFE)	
SAE AS 22759/14 (FEP-PVF_2)	
SAE AS 22759/5 (Ar-TFE)	
SAE AS22729 (FP-PI)	
SAE AS22759/33 (XL-ETFE)	

MICRO-SCALE COMBUSTION CALORIMETER TEST OF WIRES/CABLES INSULATION/JACKET



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.

Final Words

OBSERVATIONS:

	FAA 60 Degree Flammability Test		Intermediate-Scale Test		30 Degree Radiant Heat Panel Test	
Wire/Cable ID	Burn Length (cm)	Flame Extinguishing Time (sec)	Burn Length (cm)	Flame Extinguishing Time (sec)	Burn Length (cm)	Flame Extinguishing Time (sec)
BMS13-60	3.1	0.0	29.5	79.8	1.9	0.0
MS81044/6	4.9	2.3	25.7	109.8	2.7	4.3
Mil-17/28-RG58	7.1	4.0	109.8	1074.0	>15	>60

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

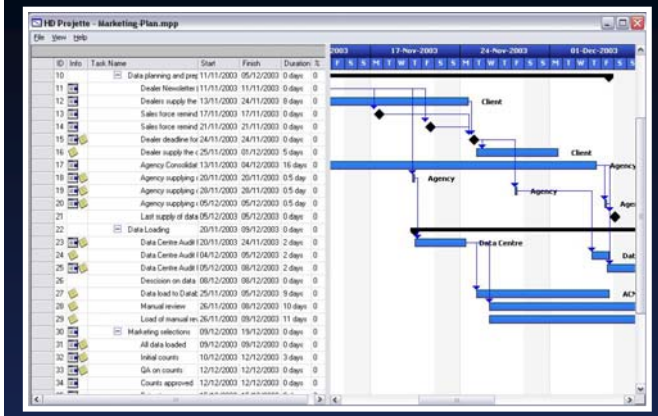
Final Words

PROJECT STATUS:

Project Tasks % Completion = 68%

Cost Performance Index = 1.05

Schedule Performance Index = 0.98



Final Words

Questions?

Go Back