



**Federal Aviation
Administration**

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

Presented to: The International Aircraft Material
Fire Testing Working Group

By: John Reinhardt, Project Manager, PMP

Date: June 17-18, 2008

Location: Niagara Falls, NY



Outline



- Project Initiating Process
 - ✓ Project Charter
 - ✓ Scope Statement
- Planning Process
 - ✓ Work Breakdown Structure
- Execution Process
 - ✓ Review Historical Information
 - ✓ Meet with Stakeholders
 - ✓ Definition of Fire Threat
 - ✓ Test Methods Selection
 - ✓ Material Selection
 - ✓ Material Testing
- Project Status & Final Words

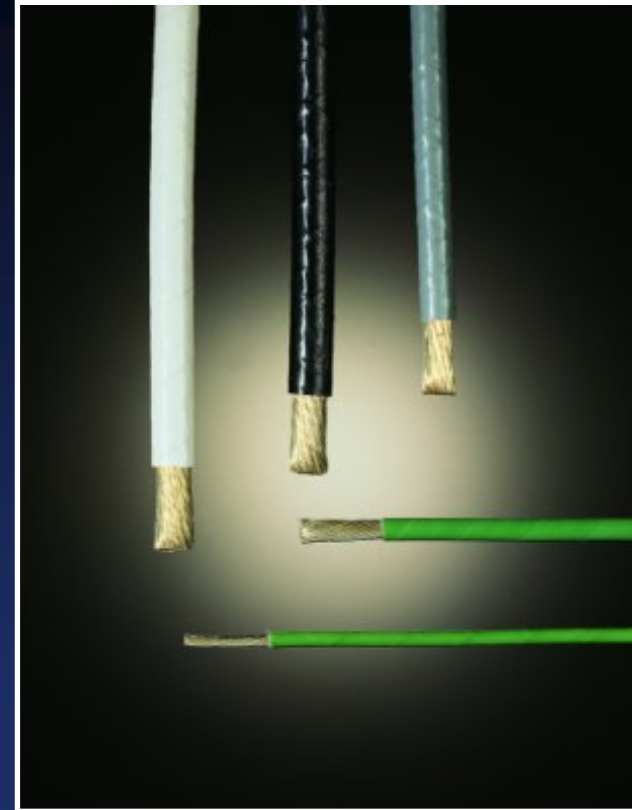


Initiating Process



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

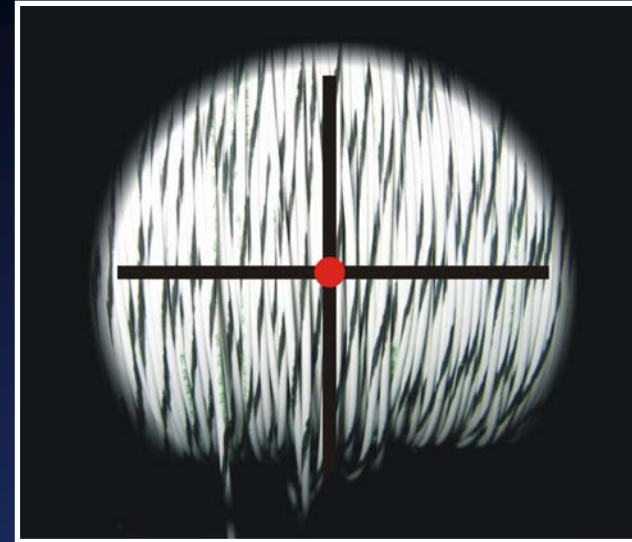


Initiating Process



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.



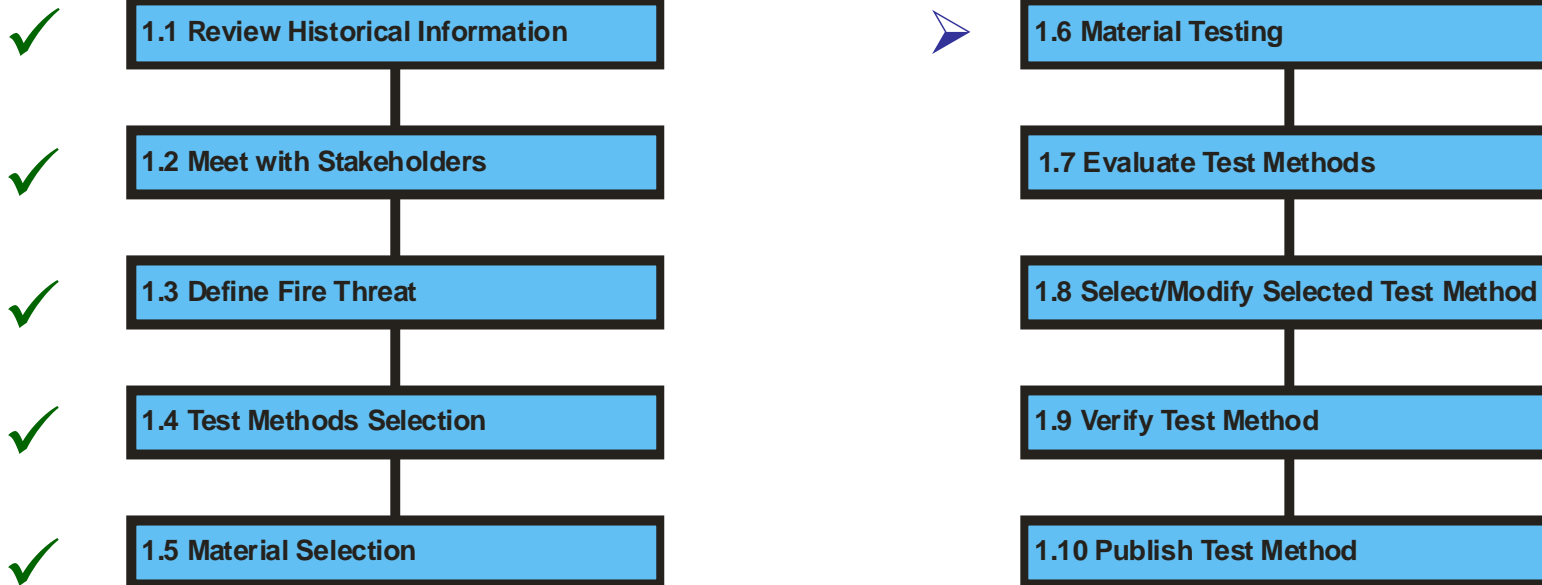
Planning Process: Scope



Work Breakdown Structure

1. NEW FLAMMABILITY TEST FOR AIRCRAFT WIRING

✓ Completed
➤ In Progress



Execution Process: WBS 1.1



WBS 1.1 Review Historical Information

Organization	Document	Flammability Test Method
Federal Aviation Administration	Appendix F Part I of 14 CFR Part 23 & 25, and Aircraft Materials Fire Test Handbook DOT/FAA/AR-00/12 Chapter 4	Sixty Degree Bunsen Burner Test
General Services Administration	Federal Test Method Standard 228	Horizontal Flammability (Method No. 5211)
		Vertical Flammability (Method No. 5221) for MIL-W rated wires
		Spark Method Flammability (Method No. 5231)
International Electrotechnical Commission	IEC 60332-3	Tests on Electric Cables Under Fire Conditions Part 3-10
National Fire Protection Association	NFPA 262	Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
SAE Aerospace Standard	Method 801	Sixty Degree Bunsen Burner Test
Underwriter Laboratory	UL 1666	Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
	UL 1685	Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

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Execution Process: WBS 1.2



WBS 1.2 Meet with Stakeholders

- FAA Sponsor
- FAA Program Manager
- FAA Fire Safety Researchers
- International Aircraft Materials Fire Test Working Group
- OEMs
- Other



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Execution Process: WBS 1.3



WBS 1.3 Define Fire Threat

- Report DOT/FAA/AR-99/44 – “Development of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation,” September 2000
- And, Report DOT/FAA/AR-08/4 – “Development of an Improved Fire Test Method for Aircraft Ducting,” February 2008
- **Fire Threat:** 101.6 by 101.6 by 228.6-mm Urethane Foam Block (Density: 16.02 kg/m³)
- Environment:
 - ✓ Sea Level
 - ✓ Narrow-body attic
 - ✓ Insulation blankets in attic
 - ✓ Insulated duct in attic
 - ✓ Quasi-Std Ambient Temperature

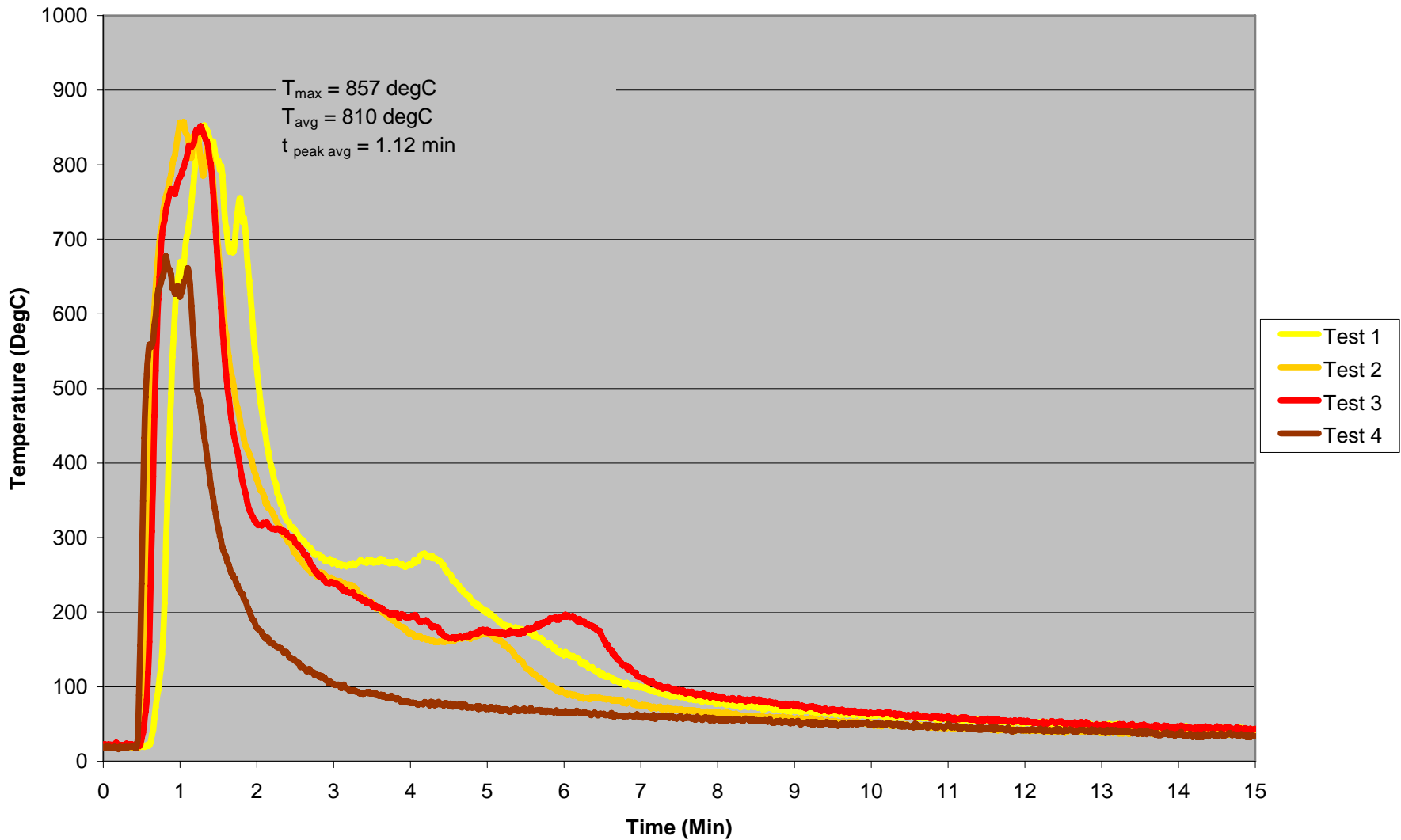


Execution Process: WBS 1.3



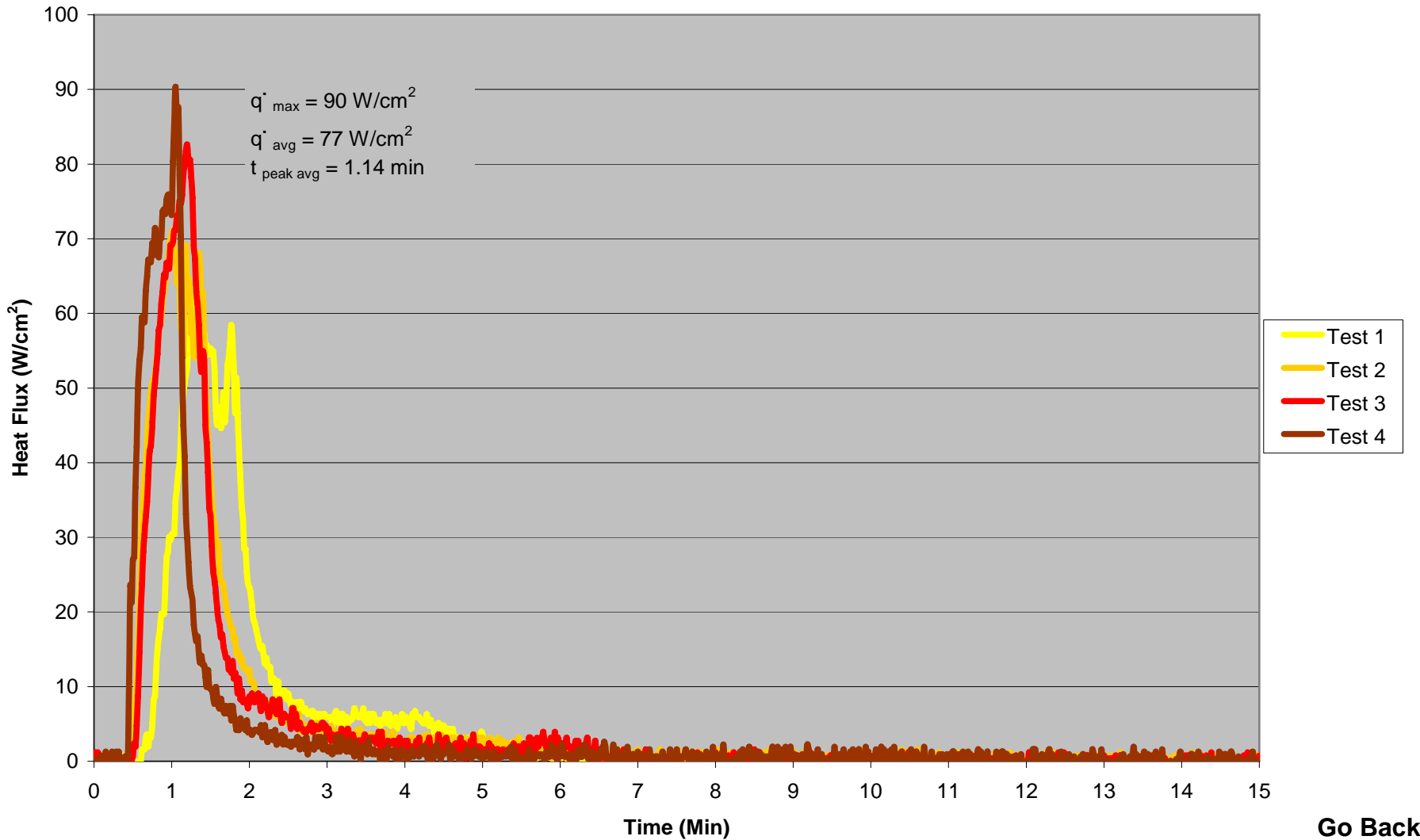
INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES

Ignition Source Temperature Profile (Baseline)



INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES

Ignition Source Heat Flux Profile (Baseline)



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Execution Process: WBS 1.4



WBS 1.4 Test Methods Selection

MEASUREMENT	MATERIAL TEST METHOD			
	60-Degree Bunsen Burner Test	Intermediate-Scale	Microscale Combustion Calorimeter	Radiant Heat Panel
Fire Propagation	●	●		●
Burn Area		●		
After Flame Time	●	●		●
Drip Flame Time	●			
Total Heat Release			●	
Heat Release Rate			●	
Onset Temperature			●	
Combustion Temperature			●	
% Char			●	

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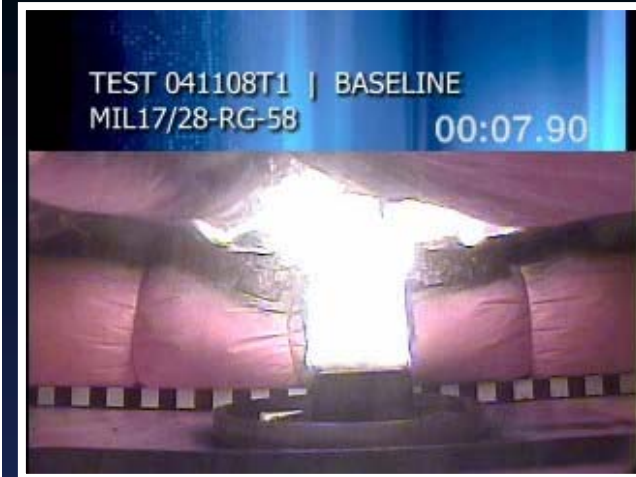
Item No.	Wire Specification	AWG	Insulation Material	Jacket Material	Temp Rating (degC)	Comments
1	Hitachi Riser Cable Cat 3		PVC	Fire Retardant Thermoplastic	60	Other Industry Usage
2	Hitachi Riser Cable (Cat 5e:)		Polyolefin	Fire Retardant Thermoplastic	60	Use in other Industries; POLYOLEFIN: Polyethylene, Polypropylene, Cellular Polyolefin, Flame Retardant PE?
3	Computer Cable Polypropylene Insulated, Belden 9804, 28 AWG, 2 pairs, shield: 90% overall foil/braid, drain wire overall		Polypropelene	PVC	60	Use in other Industries
4	M17/28-RG58 (Coaxial Cable Type IIIA)		PE	PVC	80	Use in other Industries
5	Neoprene Hook-up Wire		Neoprene	-	90	Use in other Industries
6	MS 5086/1 (~ BMS13-13)	20	PVC	Nylon	105	Past Aircraft Production
7	Fiber Optic Riser Cable		-	PVC	105	Use in other Industries
8	Hypalon Hook-up Wire		Hypalon	-	105	Use in other Industries
9	SAE AS 22759/14	20	Extruded FEP	PVDF	135	Aircraft acceptable protected wire listed on FAA's Advisory Circular 43.13-1B Table 11-12, Past Aircraft Production
10	MS22759/16	20	ETFE	-	150	Aircraft acceptable open wire listed on FAA's Advisory Circular 43.13-1B Table 11-11
11	MS 22759/32	20	Zelrad 150-S, XL-ETFE	-	150	Aircraft acceptable protected wire listed on FAA's Advisory Circular 43.13-1B Table 11-12; Current In-Flight Entertainment/Other Passenger Systems
12	BMS13-48 (~ MS 22759/34)	20	ETFE	-	150	Aircraft acceptable open wire listed on Advisory Circular 43.13-1B Table 11-11; Current Aircraft Production; Aircraft, In-Flight Entertainment/Other Passenger Systems
13	BMS13-60T01C01	20	Polyimide	PTFE	150	Current Aircraft Production
14	MS 81044/6 (~ BMS13-38)	20	Crosslinked Polyalkene	PVDF	150	Aircraft acceptable open wire listed on FAA's Advisory Circular 43.13-1B Table 11-11; Past Aircraft Production
15	MS 81381/21	20	Polyimide Tape	Polyimide Resin	150	Aircraft acceptable protected wire listed on Advisory Circular 43.13-1B Table 11-12; Past Aircraft Production
16	Radix Braidless Silicone 150 Lead Wire		Silicone Rubber	-	150	Use in other Industries
17	SAE AS22759/33	20	Crosslinked ETFE Single Layer	-	200	Aircraft acceptable protected wire listed on FAA's Advisory Circular 43.13-1B Table 11-12; Current In-Flight Entertainment/Other Passenger Systems
18	BMS13-55	20	Impregnated Inorganic Fiber	PTFE	200	Current Aircraft Production
19	BMS13-72	20	PTFE	FEP	200	Current Aircraft Production
20	SAE AS 22759/5	20	Extruded PTFE	-	200	Aircraft acceptable open wire listed on FAA's Advisory Circular 43.13-1B Table 11-11; Past Aircraft Production
21	SAE AS 22759/11	20	TFE	-	200	Aircraft acceptable protected wire listed on FAA's Advisory Circular 43.13-1B Table 11-12; Past Aircraft Production
22	SAE AS22729 (MS 22759/86)	20	Composite: Fluoropolymer/Polyimide Tape	-	260	Current Aircraft Production; Current In-Flight Entertainment/Other Passenger Systems

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
 - Radiant Heat Panel Test
 - Other (as needed).



Execution Process: WBS 1.6



Wire Specification	Intermediate Scale Test	60 Degree Test	MSCC Test	RHP Test
Baseline	X	N/A	N/A	
Belden 9804 Cable(PVC-PP)	X	X	X	
BMS13-48 (Ex-XL-ETFE)		X	X	
BMS13-55 (PTFE)		X	X	
BMS13-60 (PTFE-PI)	X	X	X	
BMS13-72 (FEP-PTFE)		X	X	
Braidless Silicone 200 Lead Wire	X	X	X	
Fiber Optic Cable M9B037 (PVC)	X	X	X	
Hitachi Riser Cable Cat 3 (FR-PVC)		X	X	
Hitachi Riser Cable Cat 5e: (FR-PO)		X	X	
Hypalon Hook-up Wire	X	X	X	
M17/28-RG58 (PVC-PE)	X	X	X	
MS 22759/16 (ETFE)		X	X	
MS 22759/32 (Z-XL-M-ETFE)		X	X	
MS 5086/1 (Nylon-PVC)	X	X	X	
MS 81044/6 (XL-PA)	X	X	X	
MS 81381/21 (PI)		X	X	
Neoprene Hook-up Wire		X	X	
SAE AS 22759/11 (TFE)	X	X	X	
SAE AS 22759/14 (FEP-PVF ₂)		X	X	
SAE AS 22759/5 (Ar-TFE)		X	X	
SAE AS22729 (FP-PI)		X	X	
SAE AS22759/33 (XL-ETFE)		X	X	

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 ($T > 954^{\circ}\text{C}$), perpendicular to wire sample
 - **Heat Source Exposure:** 30 seconds
 - **Flame Extinguishing Time:** <30 secs
 - **Burn Length:** <7.6 cm
 - **Drip Extinguishing Time:** <3 sec





Wire Sample: BMS13-60 (Passed B.L. = 2.9 cm, FET = 0 sec)





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

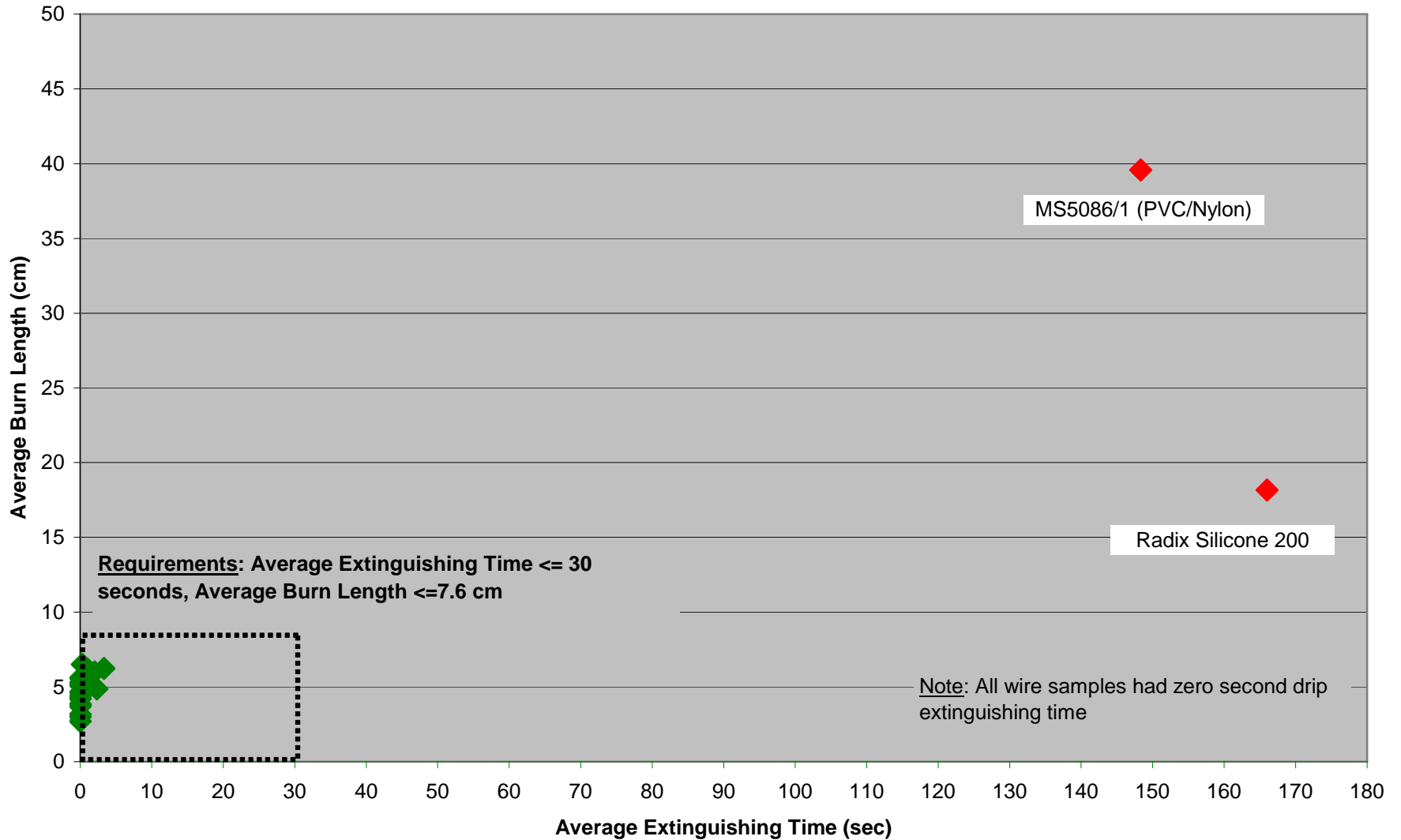




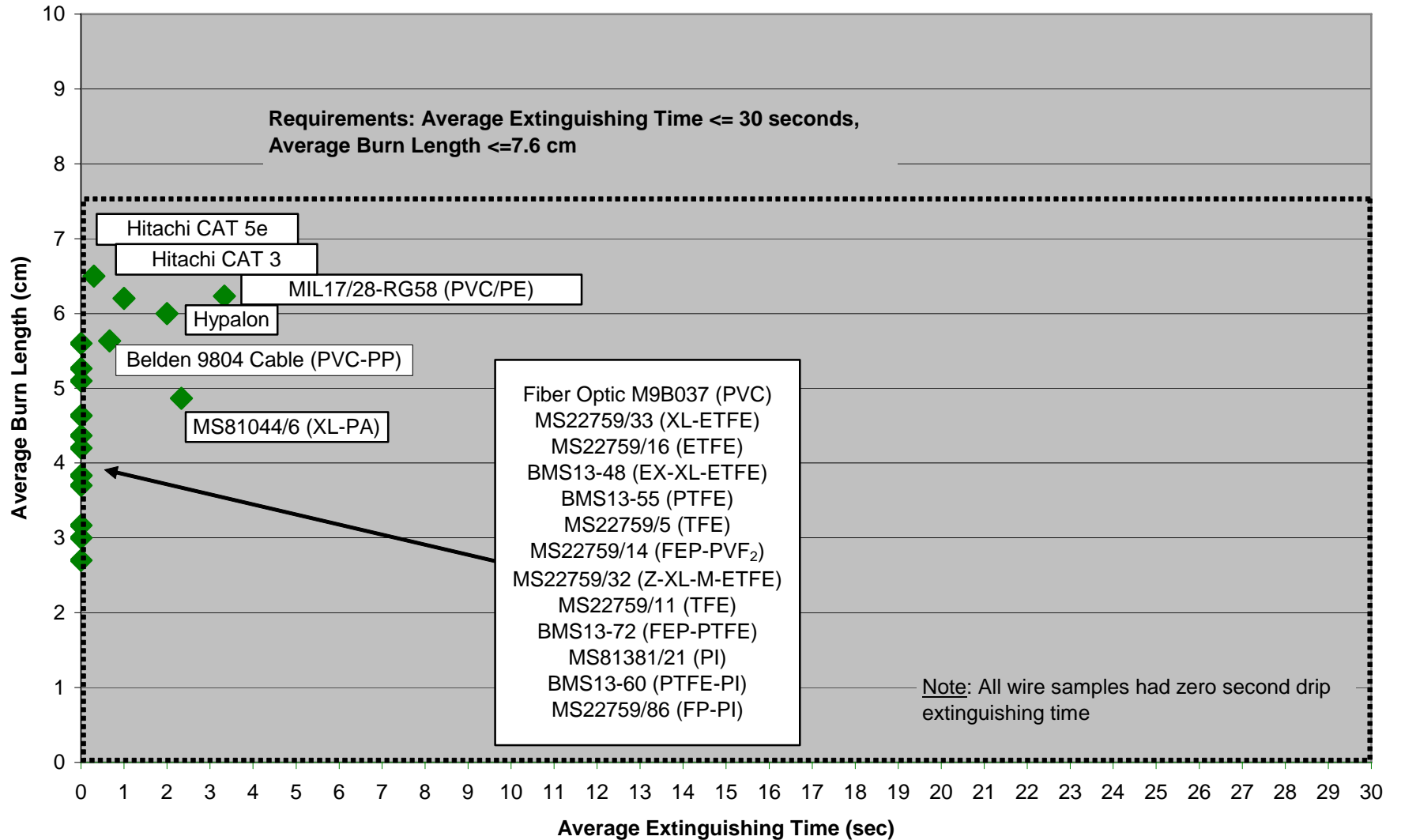
Wire Sample: MS5086/1 (PVC/Nylon, Failed: B.L. = 39.5 cm, FET = 156 sec)



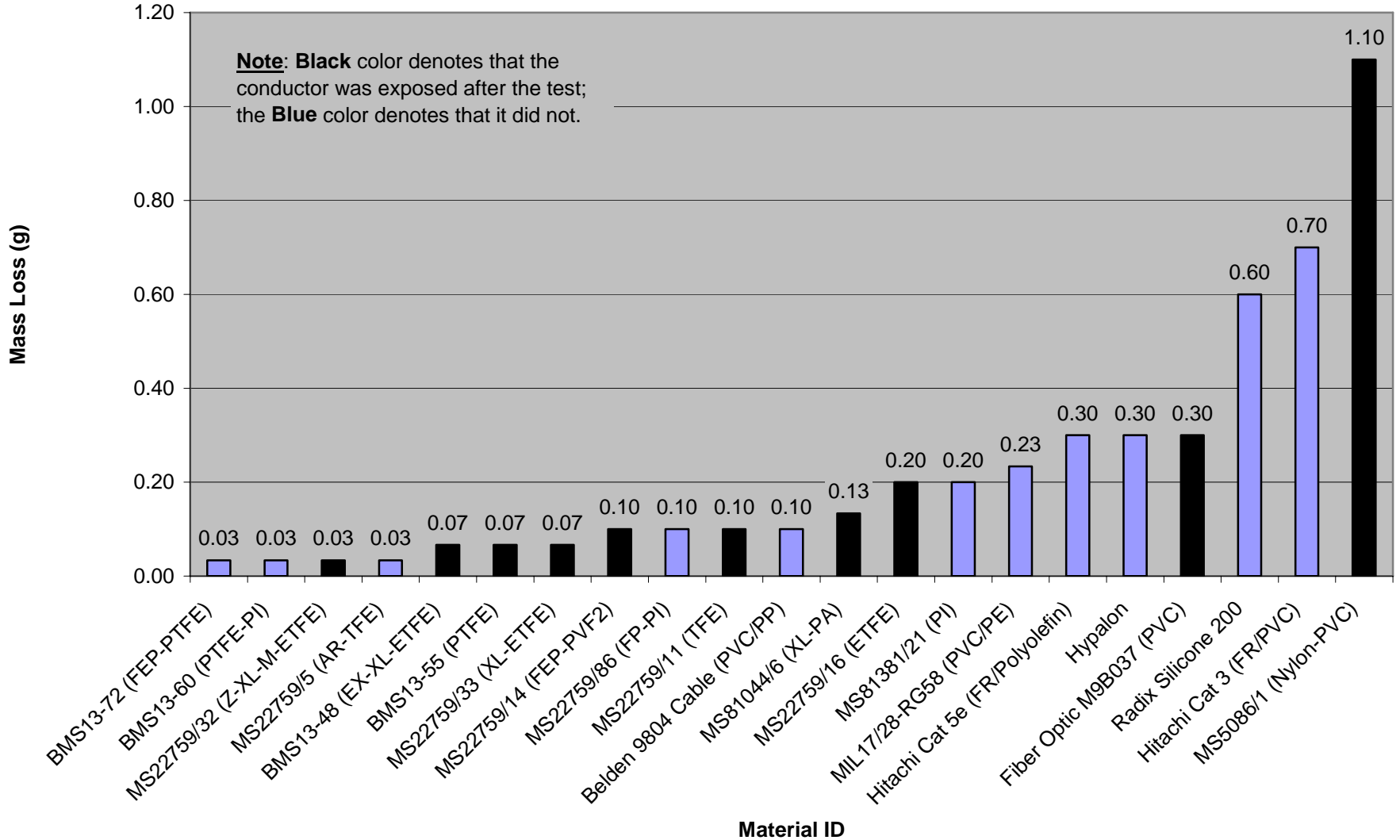
FAA 60-DEGREE BUNSEN BURNER TEST FOR ELECTRIC WIRE



FAA 60-DEGREE BUNSEN BURNER TEST FOR ELECTRIC WIRE



FAA 60-DEGREE BUNSEN BURNER TEST FOR ELECTRIC WIRE



Execution Process: WBS 1.6



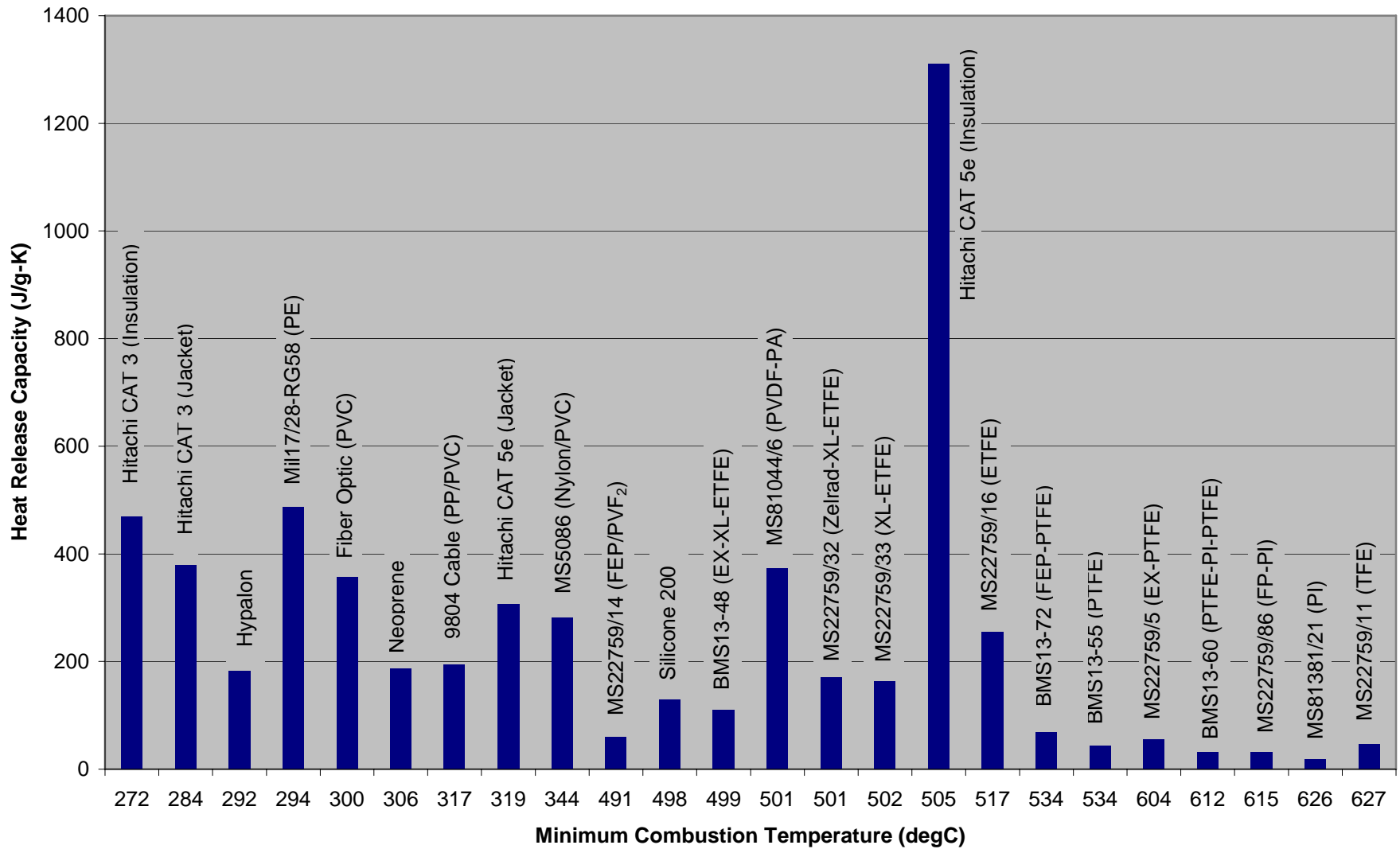
WBS 1.6 Material Testing

- **MICRO-SCALE COMBUSTION CALORIMETER TEST**

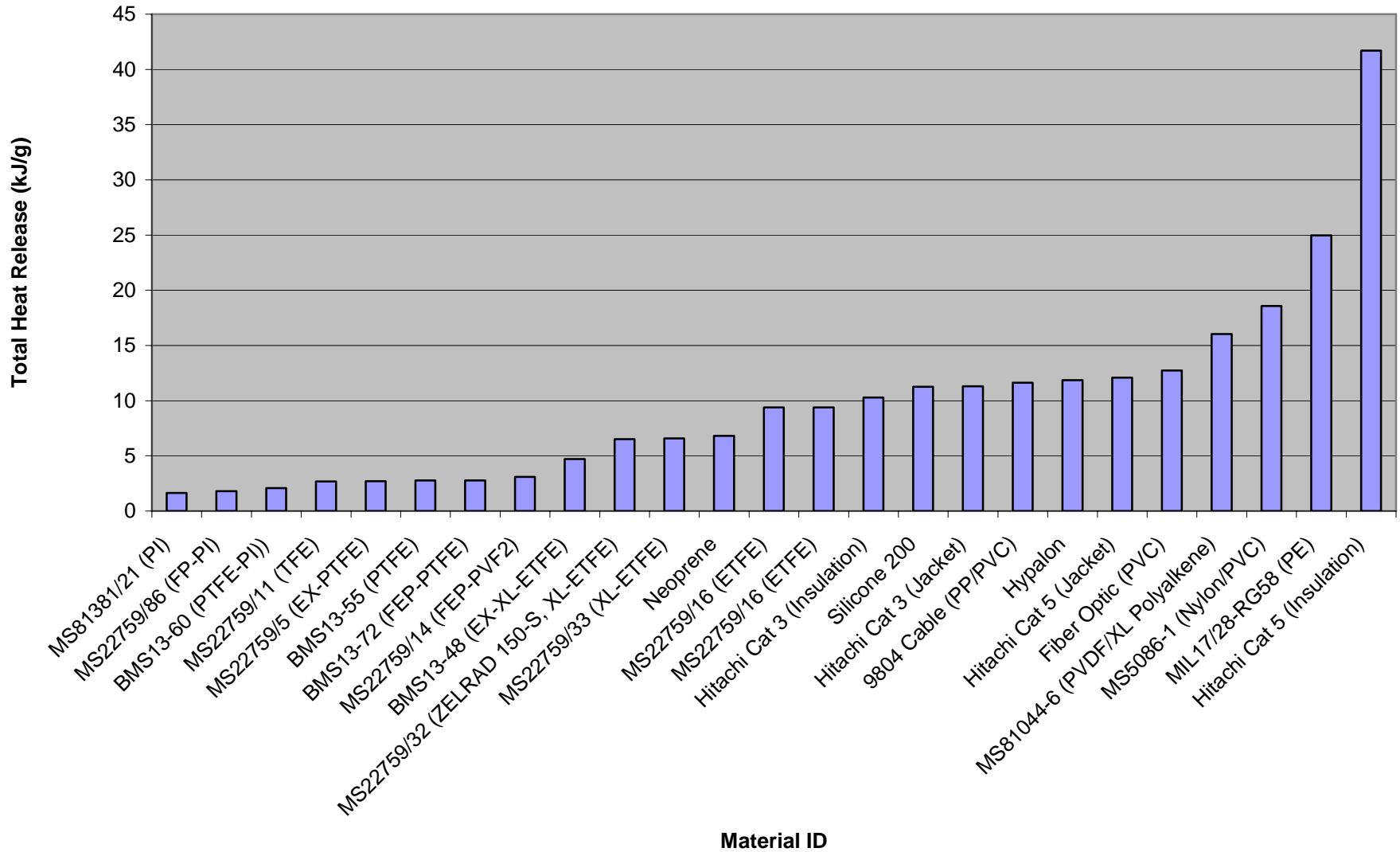
- **Test Protocol:** FAA Report DOT/FAA/AR-01/117 “A Micro-scale Combustion Calorimeter”
- **Sample Size:** milligram range
- **Heat Source:** Heating Coils (ramps up from 21 to 900 °C)
- **Heat Source Exposure:** 1°C per sec to effect pyrolysis
- **Not a compliance test**



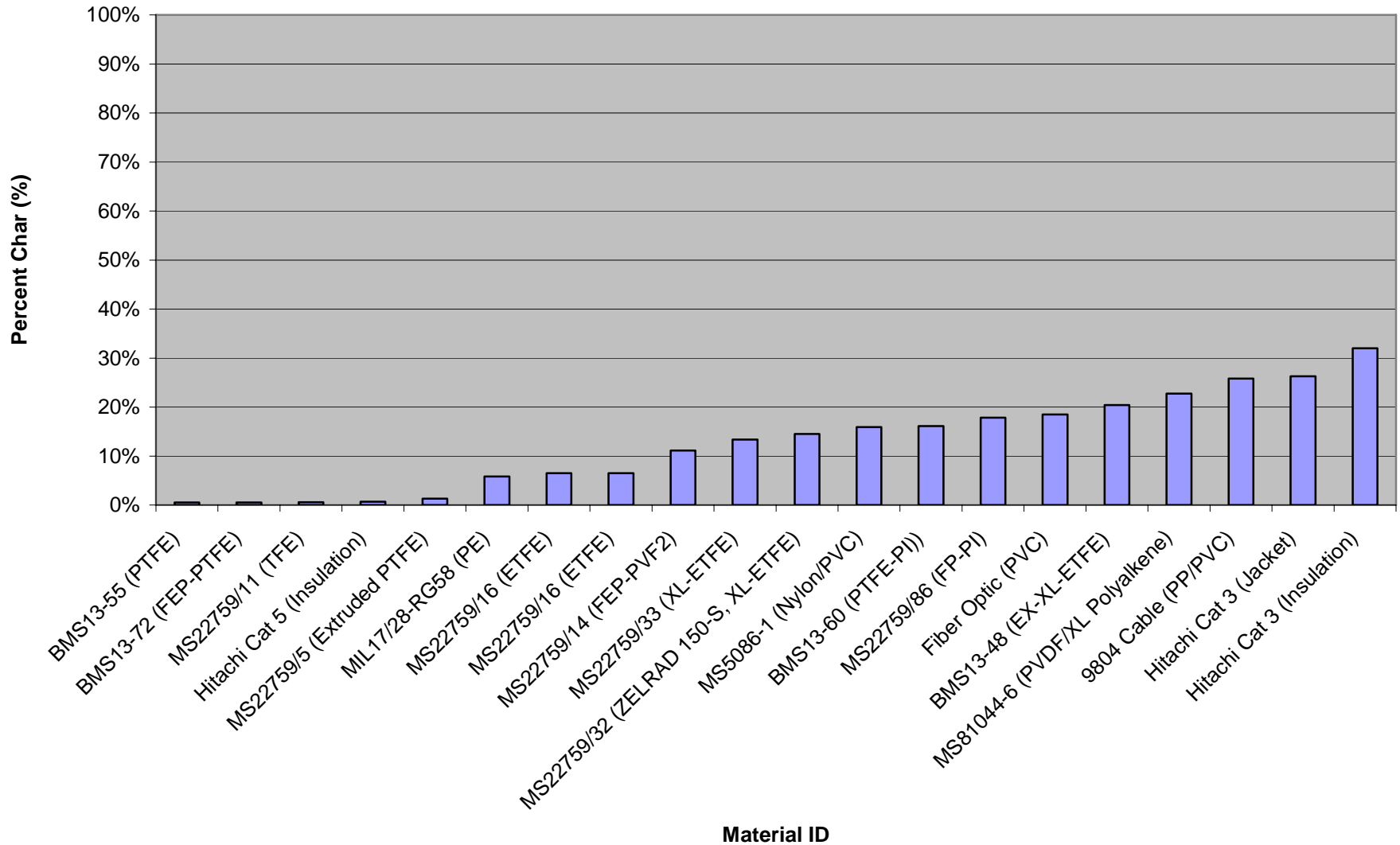
MICRO-SCALE COMBUSTION CALORIMETER TEST OF WIRES/CABLES



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

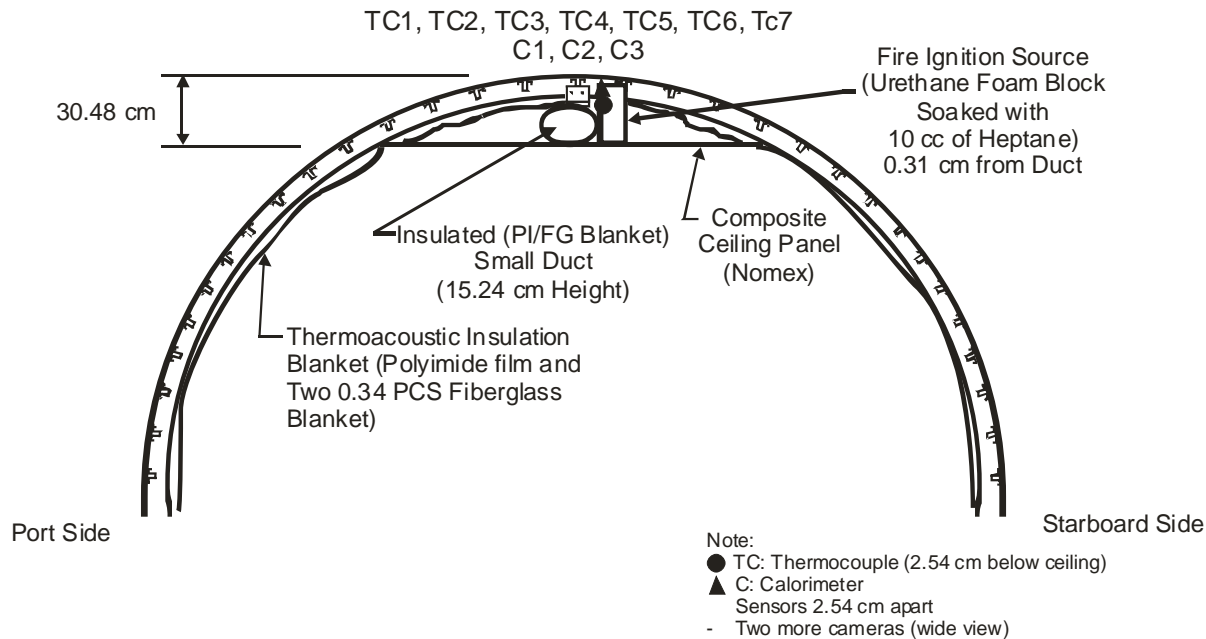
- **Test Protocol:** FAA Report DOT/FAA/AR-08/4 – “Development of an Improved Fire Test Method for Aircraft Ducting,” February 2008
- **Sample Size:** bundle of wire, 1.27 cm in diameter, 330.2 cm long
- **Heat Source:** Polyurethane Foam Block + 10 cc of Heptane (Avg HF = 77 kW/m², and Avg T = 810 °C)
- **Heat Source Exposure:** ~8 minutes; peak occurrence ~ 1min
- **Test Duration:** 15 minutes
- **Not a compliance test**



Execution Process: WBS 1.6



Intermediate-Scale Fire Test Setup – Front View

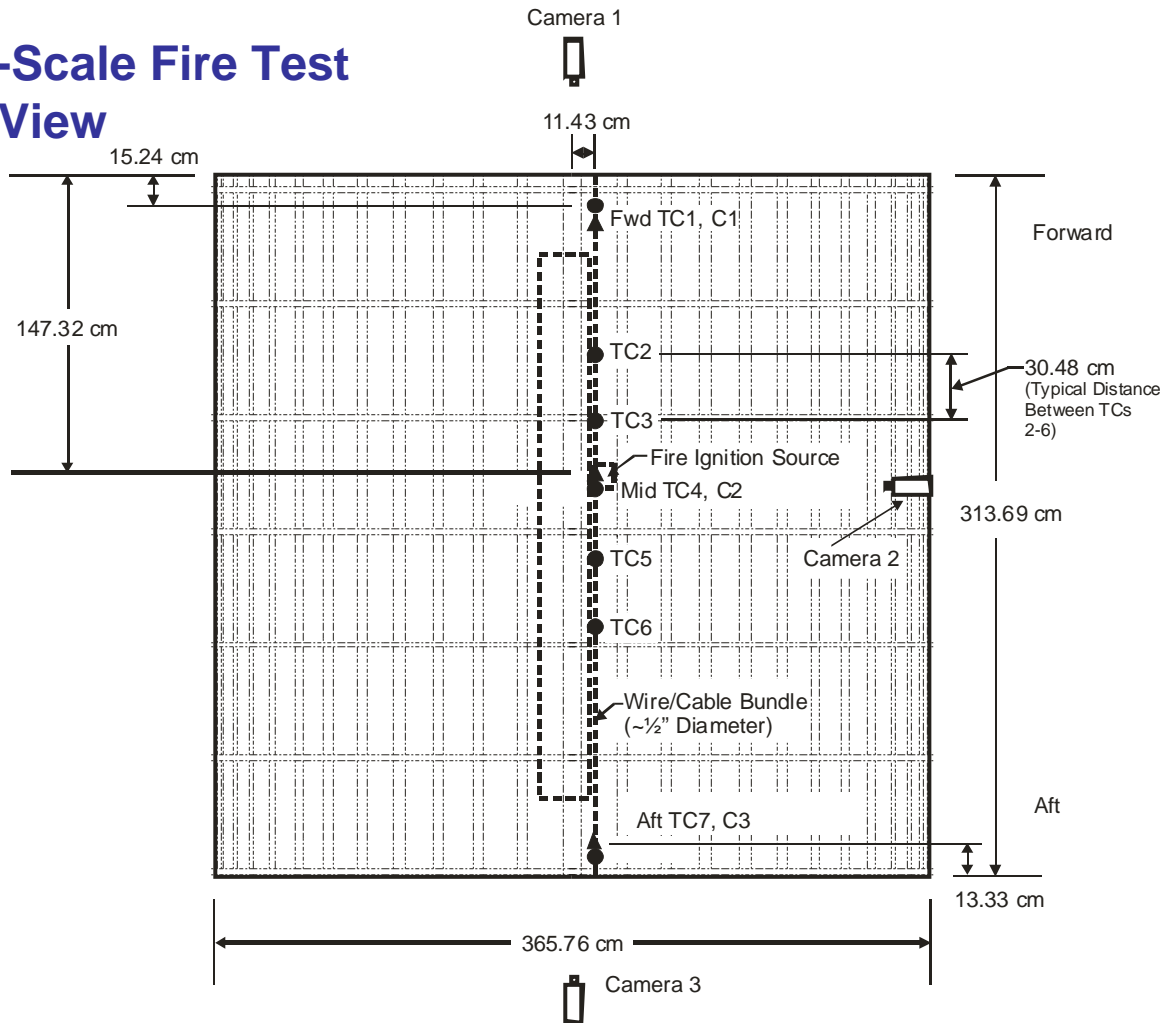


Narrow-body Transport Aircraft Fuselage Section

Execution Process: WBS 1.6



Intermediate-Scale Fire Test Setup – Top View



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



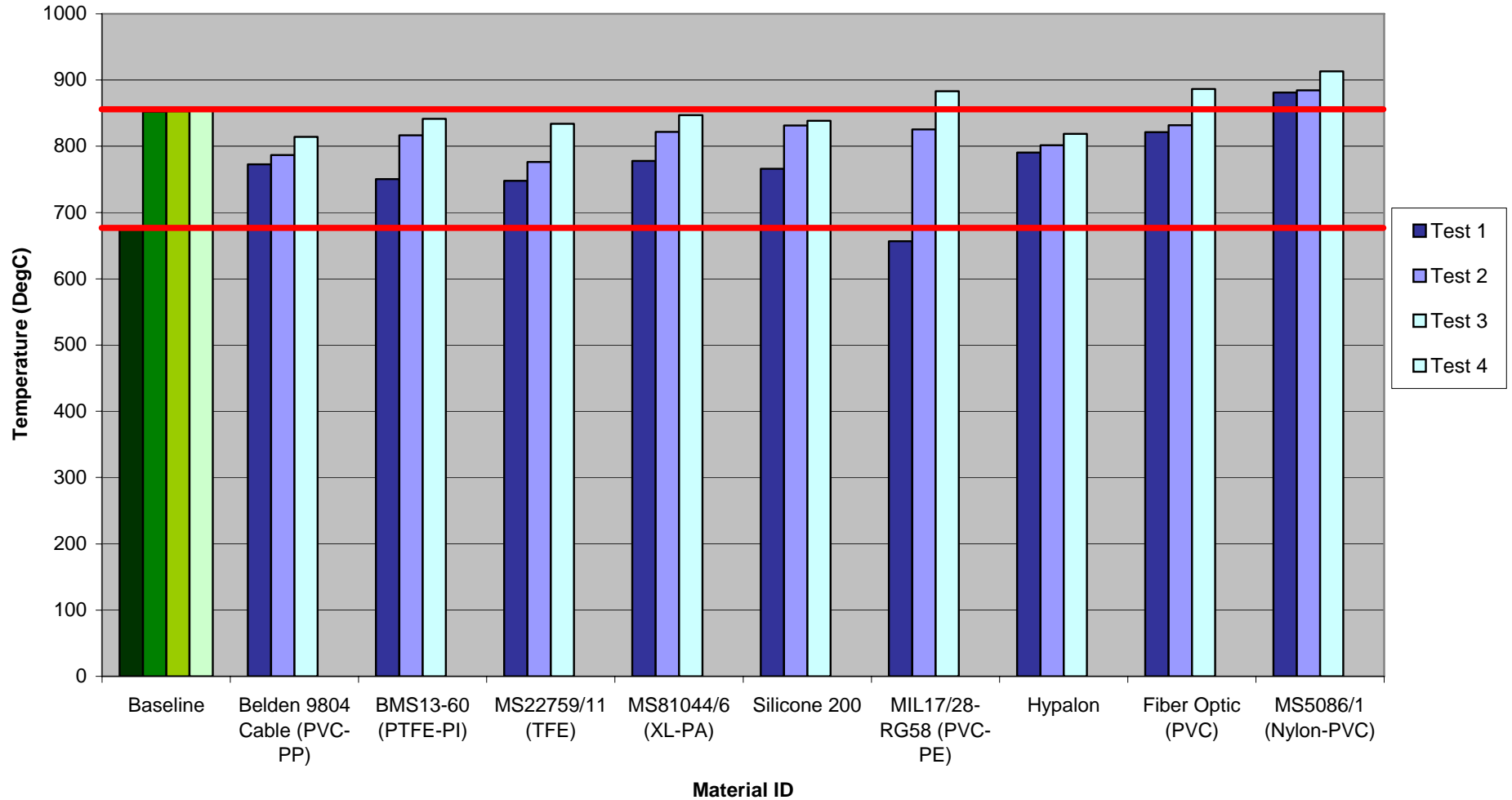
Execution Process: WBS 1.6



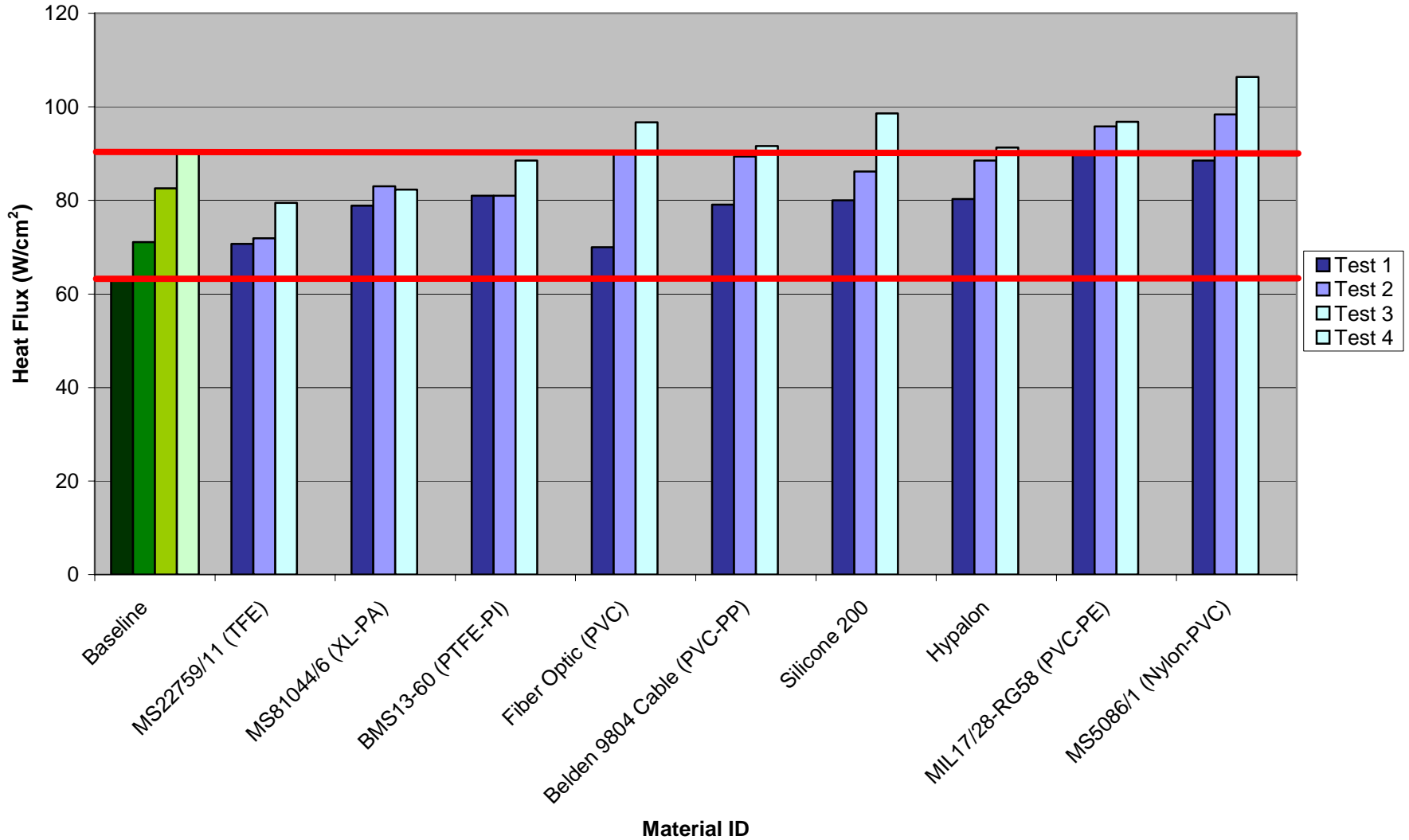
Wire Sample: MS5086/1 (B.L. = 101.7 cm, FET = 9.45 min)



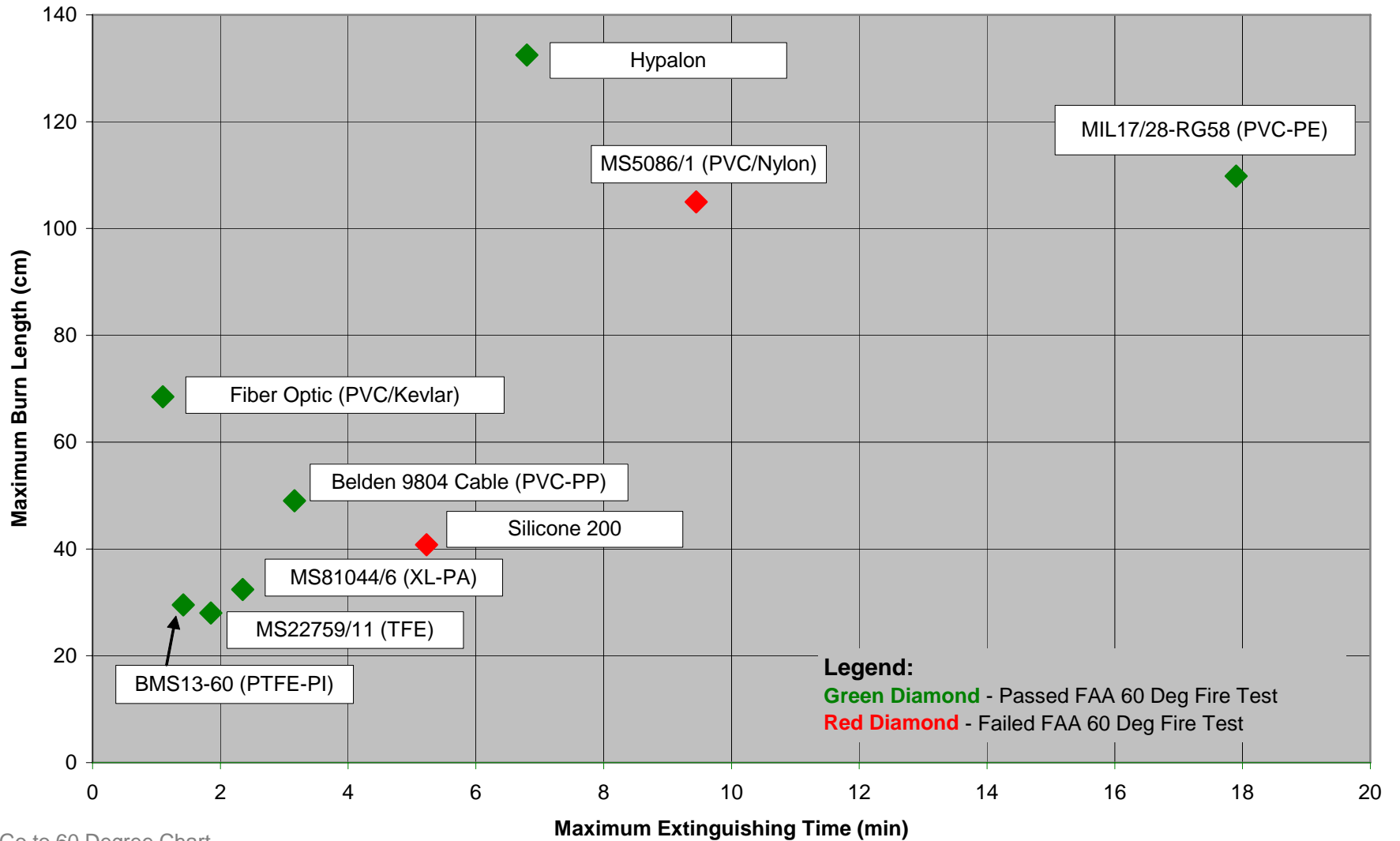
INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES



INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES

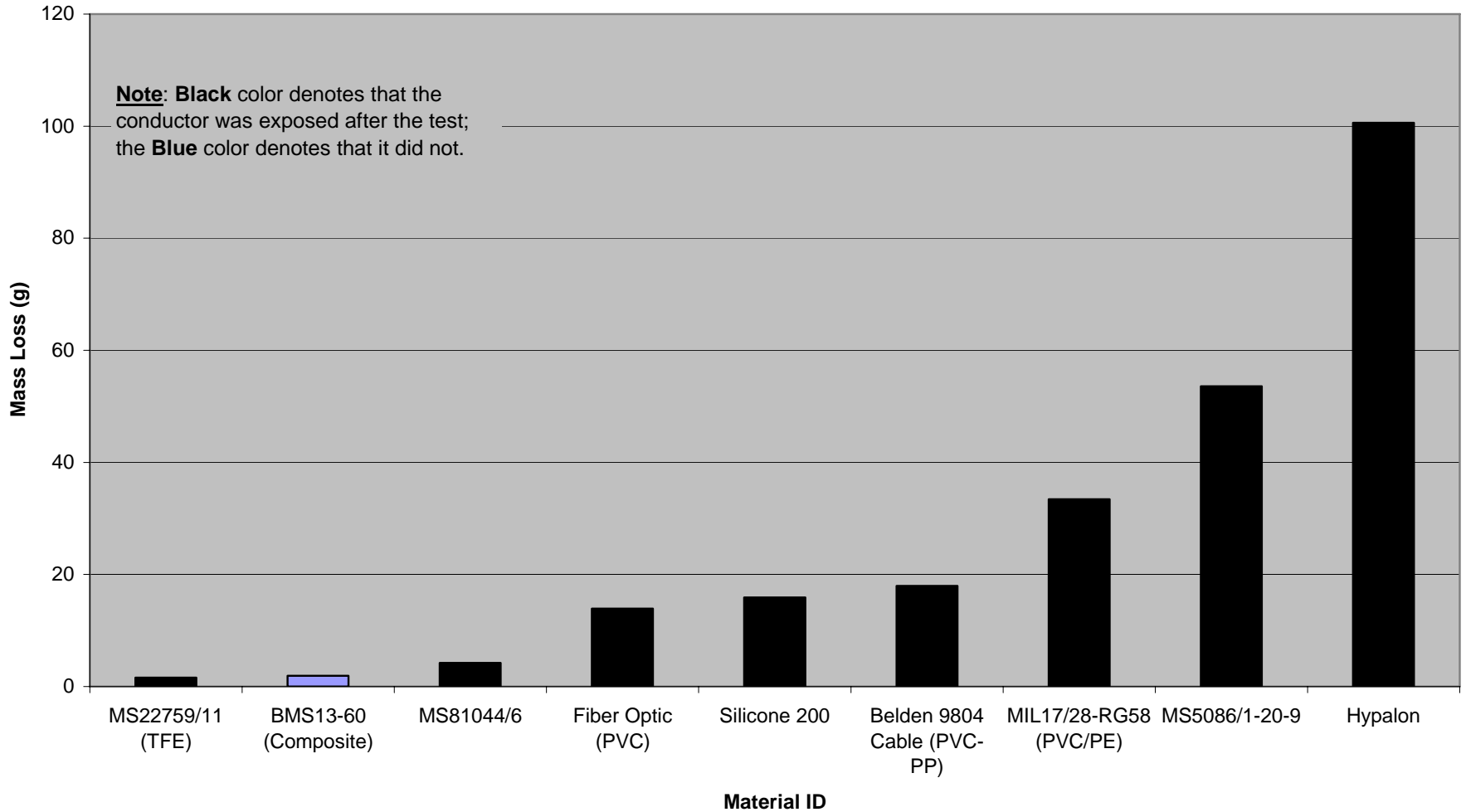


INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES



Go to 60 Degree Chart

INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES



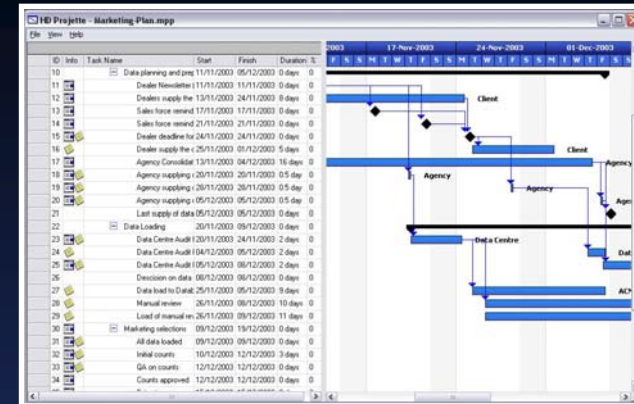
Project Status



Project Tasks % Completion = 61%

Cost Performance Index = 1.02

Schedule Performance Index = 0.99



Final Words



Questions?

Anyone interested in joining this task group?
Task group (participatory discussion)
meeting tomorrow.



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