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

PROJECT STATUS

Presented to: The International Aircraft Material Fire Testing Working Group

By: John Reinhardt, Project Manager, PMP

Date: March 4-5, 2009

Location: Naples, Florida

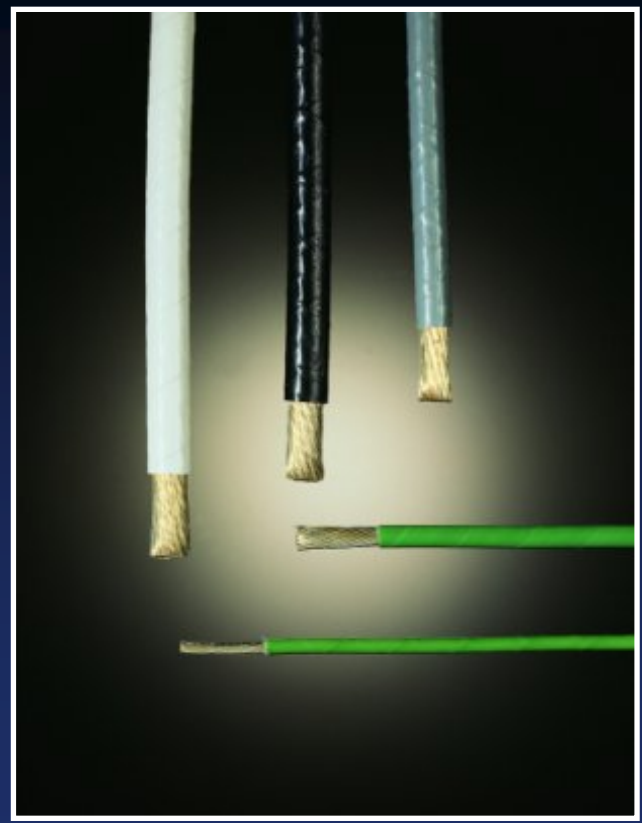
Federal Aviation Administration



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

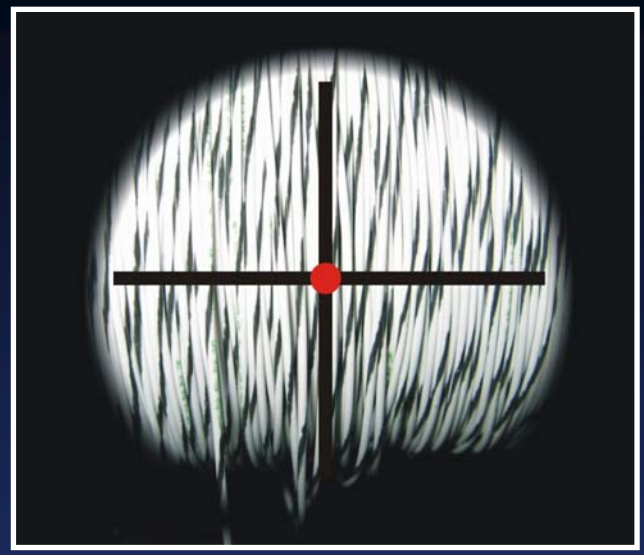


Initiating Process



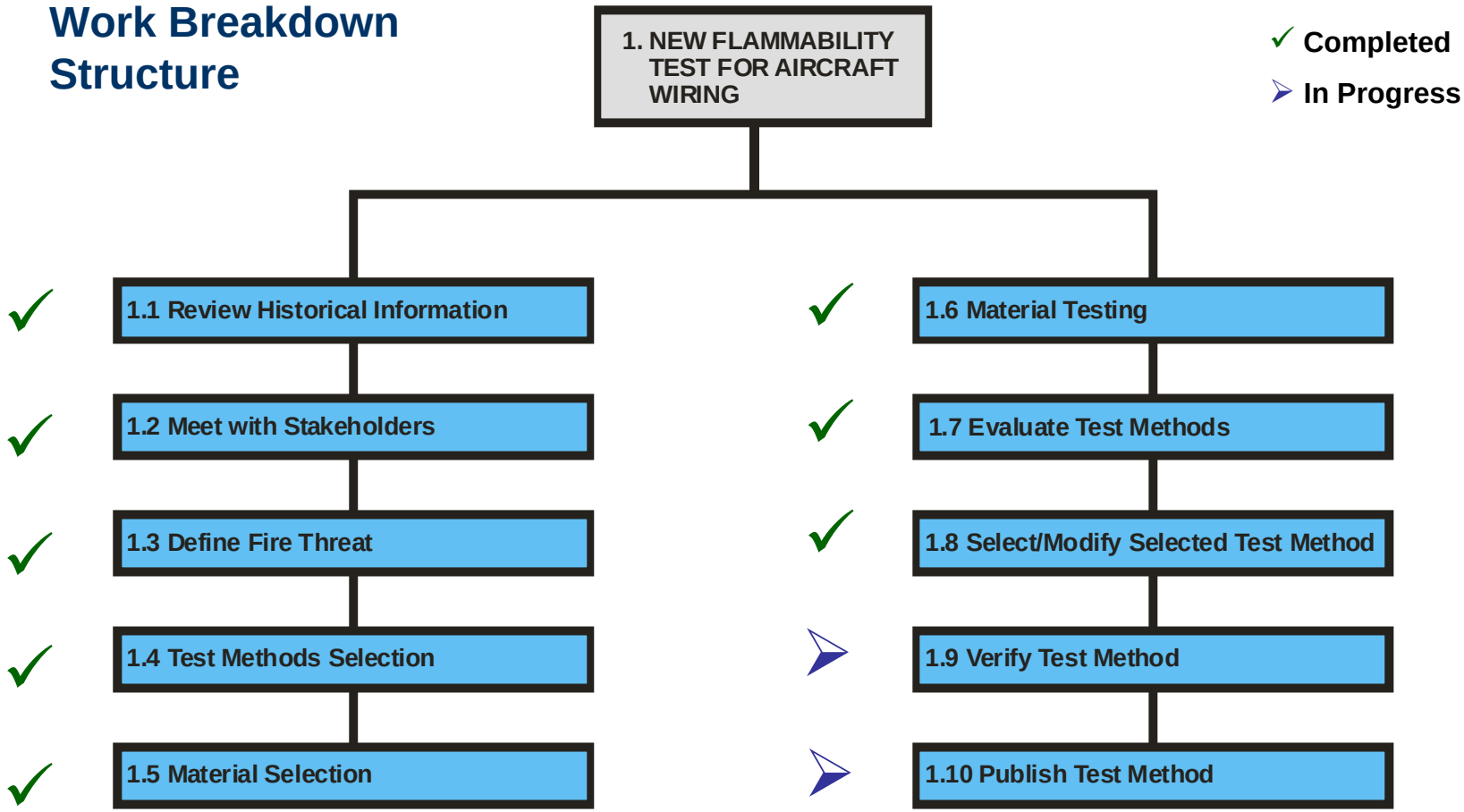
SCOPE STATEMENT

- 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

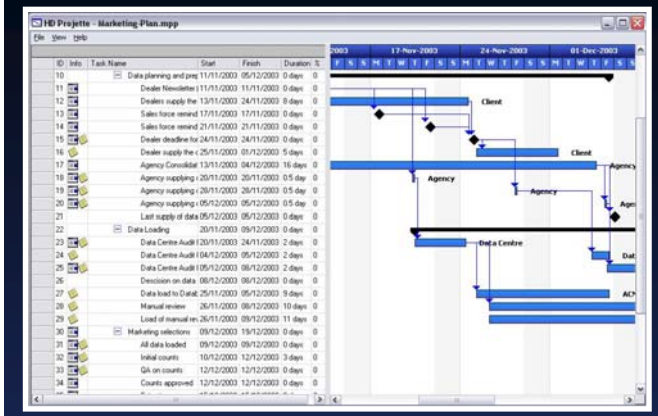


Project Status

Project Tasks % Completion = 87%

Cost Performance Index = 1.17

Schedule Performance Index = 1.02



Final Words

Questions?



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Execution Process: WBS 1.8

Select/Modify Selected Test Method

- Describe the Selected Test Procedure
- Discuss the Modification of Tests Procedures
- Address Task Group Members Questions & Requests



Execution Process: WBS 1.8

Select/Modify Selected Test Method

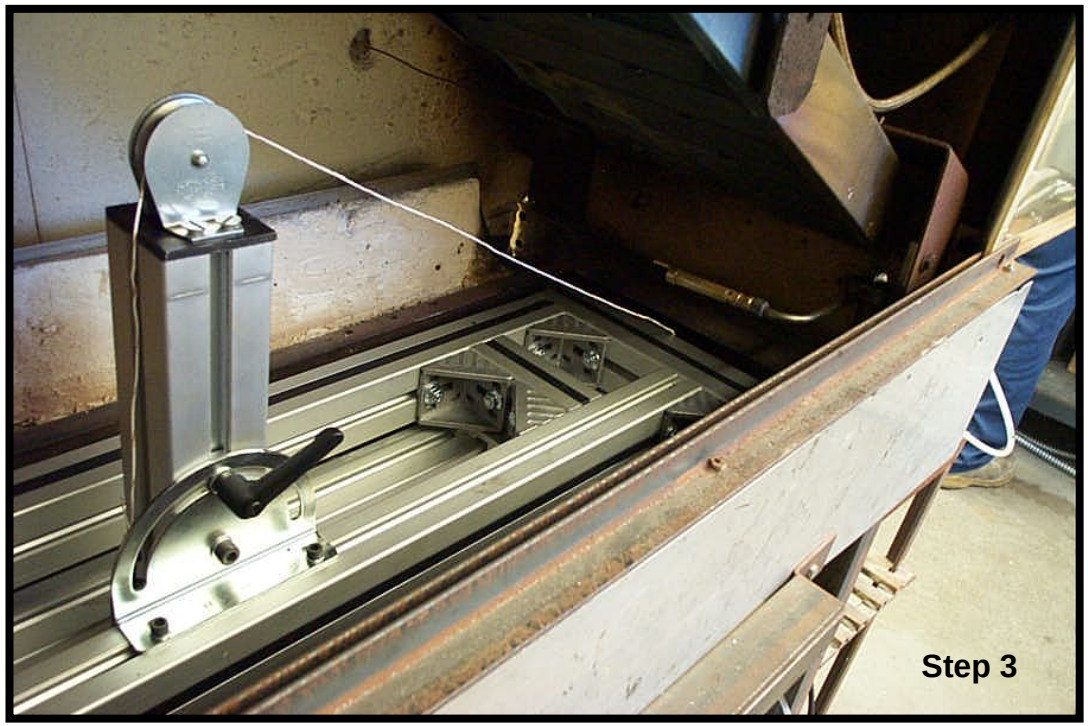
- Describe the Selected Test Procedure
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Description of Selected Test Method







Patent Pending

Execution Process: WBS 1.8

Select/Modify Selected Test Method

- Describe the Selected Test Procedure
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Execution Process: WBS 1.8



Select/Modify Selected Test Method

PROCEDURE NO.	RADIANT PANEL HEAT FLUX (Watts/cm2)	DISTANCE TO PANEL (cm)	WIRE LENGTH (cm)	WIRE GAGE SIZE (AWG)	WIRE ANGLE (Degrees)	RADIANT EXPOSURE TIME (min)	PILOT IMPINGEMENT TIME (sec)	RESULT
1	1.7	15.24	76.2	20 or cable	30	1	30	Wire broke
2	1.7	15.24	76.2	20 or cable	30	1	15	No correlation to ISF test
3	1.7	7.62	76.2	20 or cable	30	1	15	Excellent correlation to ISF
4	1.7	N/A	76.2	20 or cable	0	1	15	No correlation to ISF test
5	1.7	7.62	31.75	20 or cable	30	1	15	Excellent correlation to ISF
6	1.7	7.62	76.2	24	30	1	15	Wire broke
7	1.7	7.62	76.2	24, 10 or cable	30	1	3	Excellent correlation to ISF
8	1.7	7.62	76.2	20 or cable	30	0	3	No correlation to ISF test

Selection: Procedure number 7 provided an excellent correlation with the intermediate-scale fire test without breaking the small (24) gage wires.



ELECTRICAL WIRES/CABLES FIRE TEST RESULTS

Item No.	Wire ID	Temperature Rating	TEST		
			FAA 60 Degree Flammability Wire Test	Intermediate-Scale Fire Test	30 Degree Radiant Heat Panel Test
1	CAT3 Cable	60	Passed	Failed	Failed
2	CAT5e Cable	60	Passed	Failed	Failed
3	Computer Cable	60	Passed	Failed	Failed
4	M17/28-RG58	80	Passed	Failed	Failed
5	Neoprene	90	Passed	Failed	Failed
6	Fiber Optic Riser Cable	105	Passed	Failed	Failed
7	Hypalon	105	Passed	Failed	Failed
8	MS5086/1	105	Failed	Failed	Failed
9	MS22759/14	135	Passed	Passed	Passed
10	BMS13-48	150	Passed	Passed	Passed
11	BMS13-60	150	Passed	Passed	Passed
12	MS22759/16	150	Passed	Passed	Passed
13	MS22759/32	150	Passed	Passed	Passed
14	MS81044/6	150	Passed	Passed	Passed
15	MS81381/21	150	Passed	Passed	Passed
16	BMS13-55	200	Passed	Passed	Passed
17	BMS13-72	200	Passed	Passed	Passed
18	MS22759/11	200	Passed	Passed	Passed
19	MS22759/33	200	Passed	Passed	Passed
20	MS22759/5	200	Passed	Passed	Passed
21	Silicone 200	200	Failed	Failed	Failed
22	MS22759/86	260	Passed	Passed	Passed

Wire temp rating also based on conductor material and coatings: annealed/high strength copper with tin/silver/nickel coatings

Execution Process: WBS 1.8

Select/Modify Selected Test Method

- Describe the Selected Test Procedure
- Discuss the Modification of Tests Procedures
- Address Task Group Members Questions & Requests



Select/Modify Selected Test Method

TASK GROUP MEMBERS REQUESTS & QUESTIONS:

1. Run the 30-degree Radiant Panel Test without the radiant heat, but with only the intense pilot flame: samples to include the BMS13-60, MS81044/6, and Mil-17/28-RG58 wires and cable.

Response: Tests conducted, but results did not correlate to ISF tests data. All of the samples passed (computer cable, CAT5e cable, Neoprene, M17/28-RG-58, MS5086/1, Silicone 200).

2. Measure the temperature of the RHP and the 60 degree pilot flames

Response: RHP > 2000 degF and FAA 60 degree Test > 1750 degF, respectively.

3. Run the same 3 samples using the 30-degree RHP test with the 60-degree pilot flame intensity.

Response: Not ran, some cables were self-igniting even without pilot impingement during some of the tests. (See **movie**).

4. Film the wire with a FLIR camera to see if there is a heat sink effect due to the weight.

Response: Wire was filmed with an IR camera and it showed how the wire/cable warmed up. (See **movie**).

Select/Modify Selected Test Method

5. Test a bundle of wire wrapped with heat shrink

Response: I received the cable samples last week and started testing (M230 53/5-307-0 and NTFR-1/4-0-SP).

6. Send wire/cable samples to a few members for a round-robin to re-do some of the 60 Degree Flammability tests, especially the ones that passed the test, but failed the ISF test.

Response: Not ran. Some of these poorly performing samples, see Request #1, passed when impinged with the RHP pilot without the radiant heat.

7. Members would like to see the length of the wire sample reduced from 30 inches to something less.

Response: This request is plausible since during the short wire test no change in flammability performance was observed on the tested wires.

8. Members would like clamp ends of wire/cable samples instead of using weight. The weight seems to promote wire breakage.

Response: A few tests were conducted by clamping the ends of both sides of the wire, but it made it more difficult to mount the wire sample before each test. A reduction on pilot impingement time (3 seconds) prevented the smaller gage wires from breaking.



Select/Modify Selected Test Method

9. Members would like to include a special condition in the test to address the mounting of short wires (for samples less than 30 inches); for example, using alligator clips to attach to a longer wire or tying to a longer wire with a non-flammable mechanical means.

Response: The alligator clip technique was used to mount shorter wires on the fixture very successfully without affecting the flammability performance of the wires/cables tested. (See **photo** and **movie**)

10. Members would like to continue using the average burn length and average after flame extinguishing time as in the original test.

Response: Results data shows that the average burn length and average flame extinguishing time can be used because aviation wires tend to have very small standard deviations. The Burn Length and Flame Extinguishing Time standard deviations for the group were 0.16 cm and 2.2 seconds, respectively.

11. Members requested the testing of the same 3 wires on a horizontal position and perpendicular to the pilot flame.

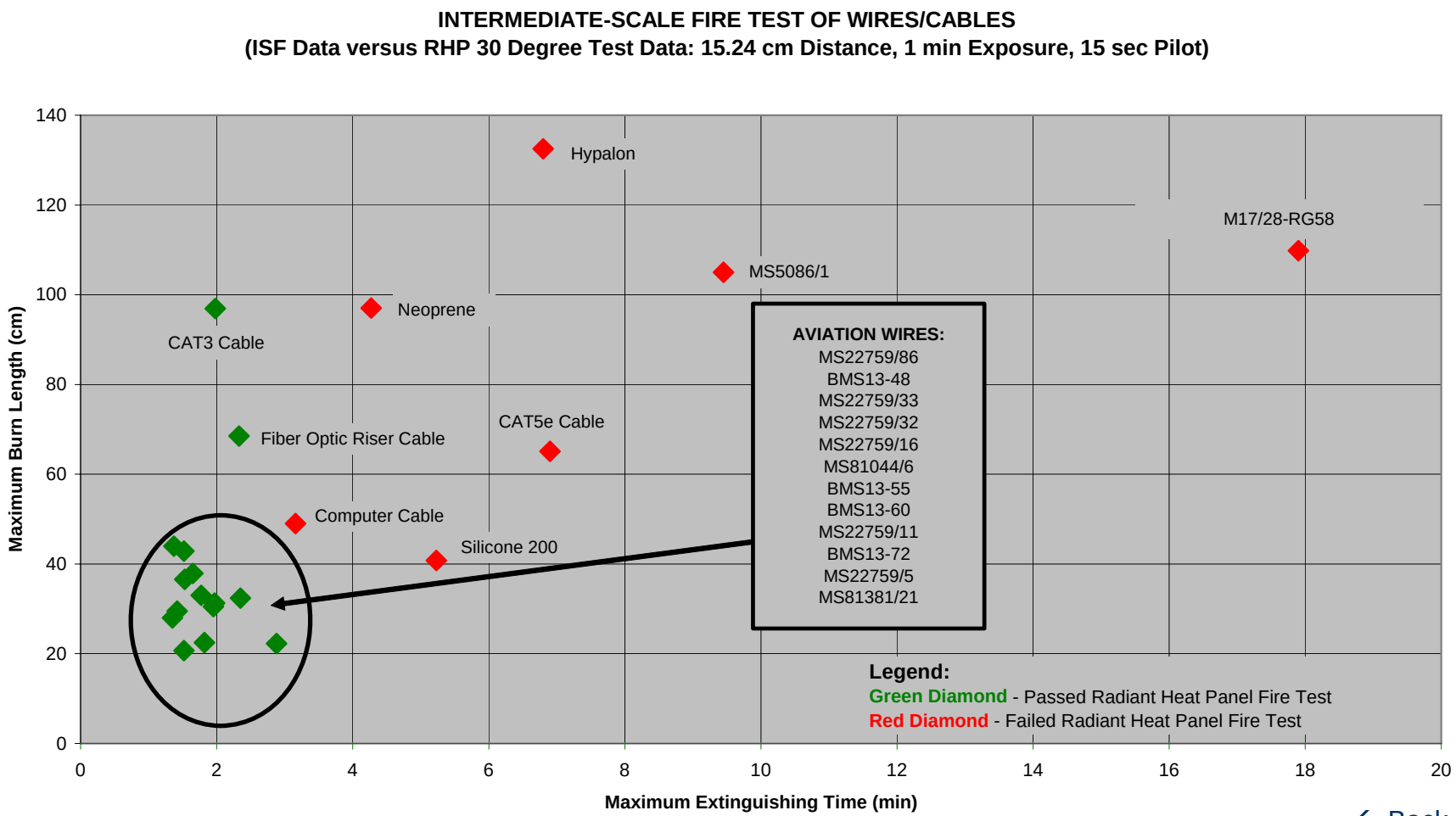
Response: A few tests, using the marginal cable samples, were conducted by installing the wire horizontally; unfortunately, not all of the cables behaved as they needed to correlate with the ISF test. (See **photo**, **data**, and **movie**)

12. Re-invite members to join online group forum.

Response: Participating task group members were re-invited on October 2008.

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Execution Process: WBS 1.8

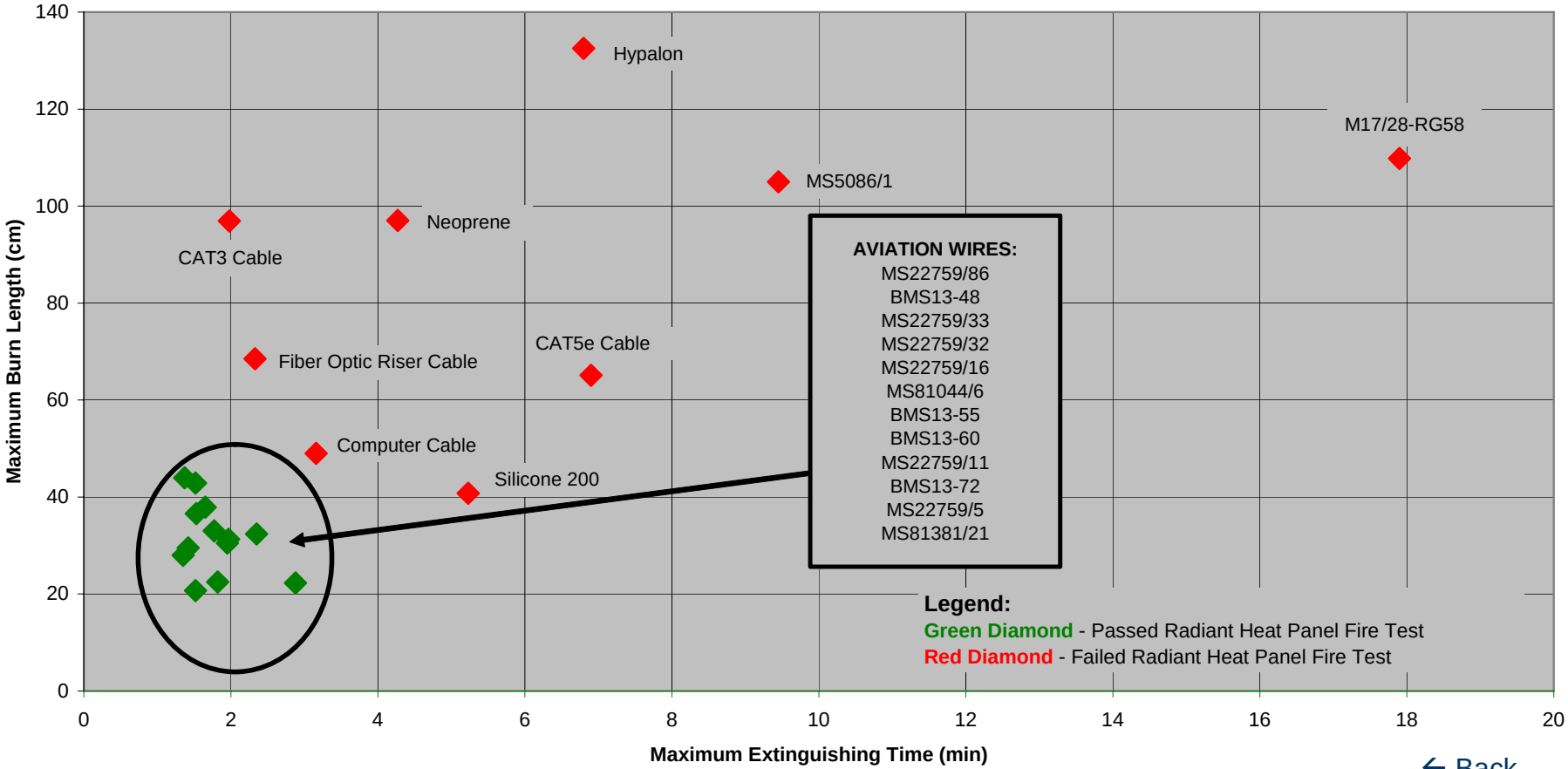


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Execution Process: WBS 1.8



INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES
(ISF Data versus RHP 30 Degree Test Data: 7.62 cm Distance, 1 min Exposure, 15 sec Pilot)

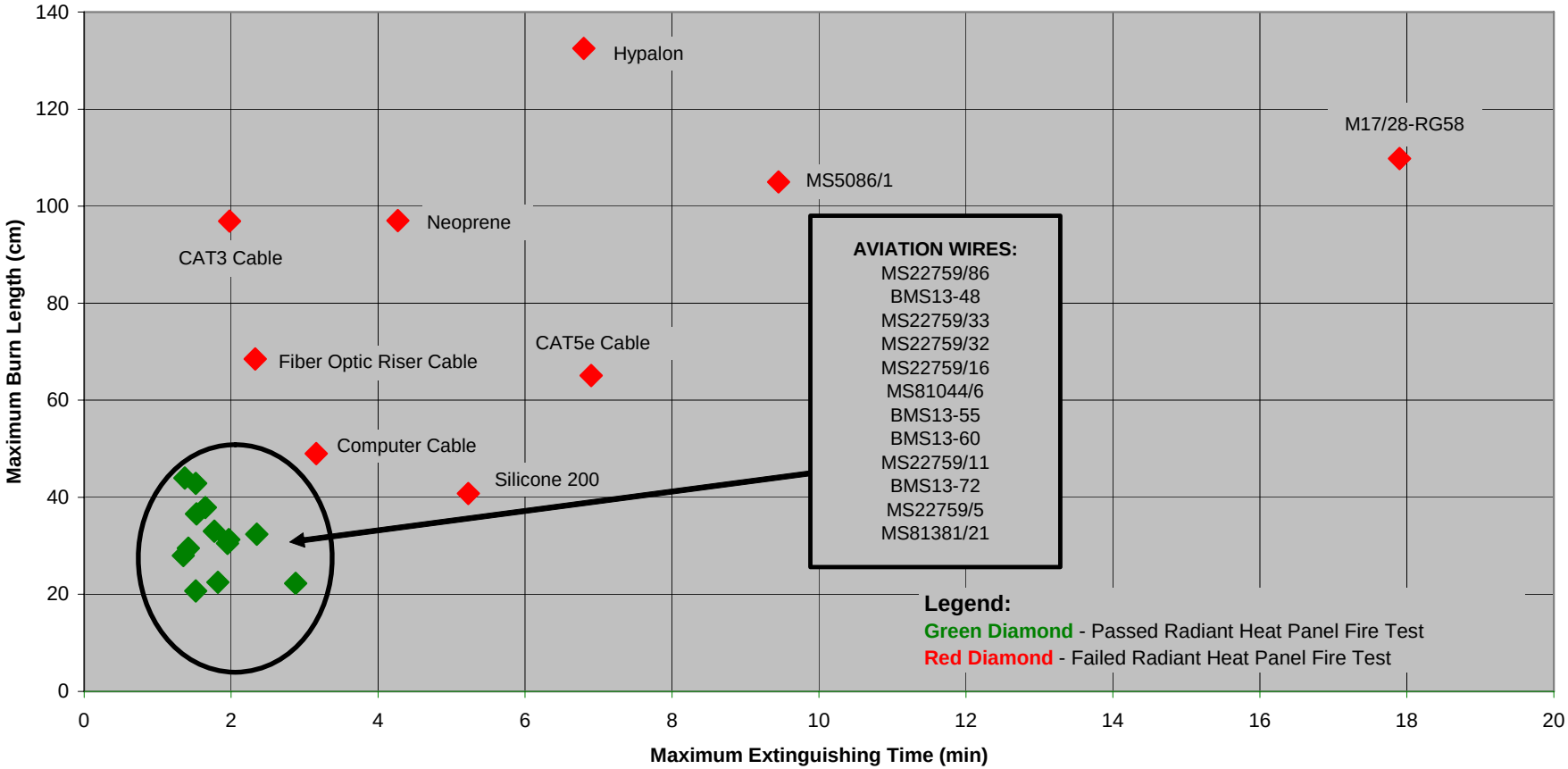


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Execution Process: WBS 1.8

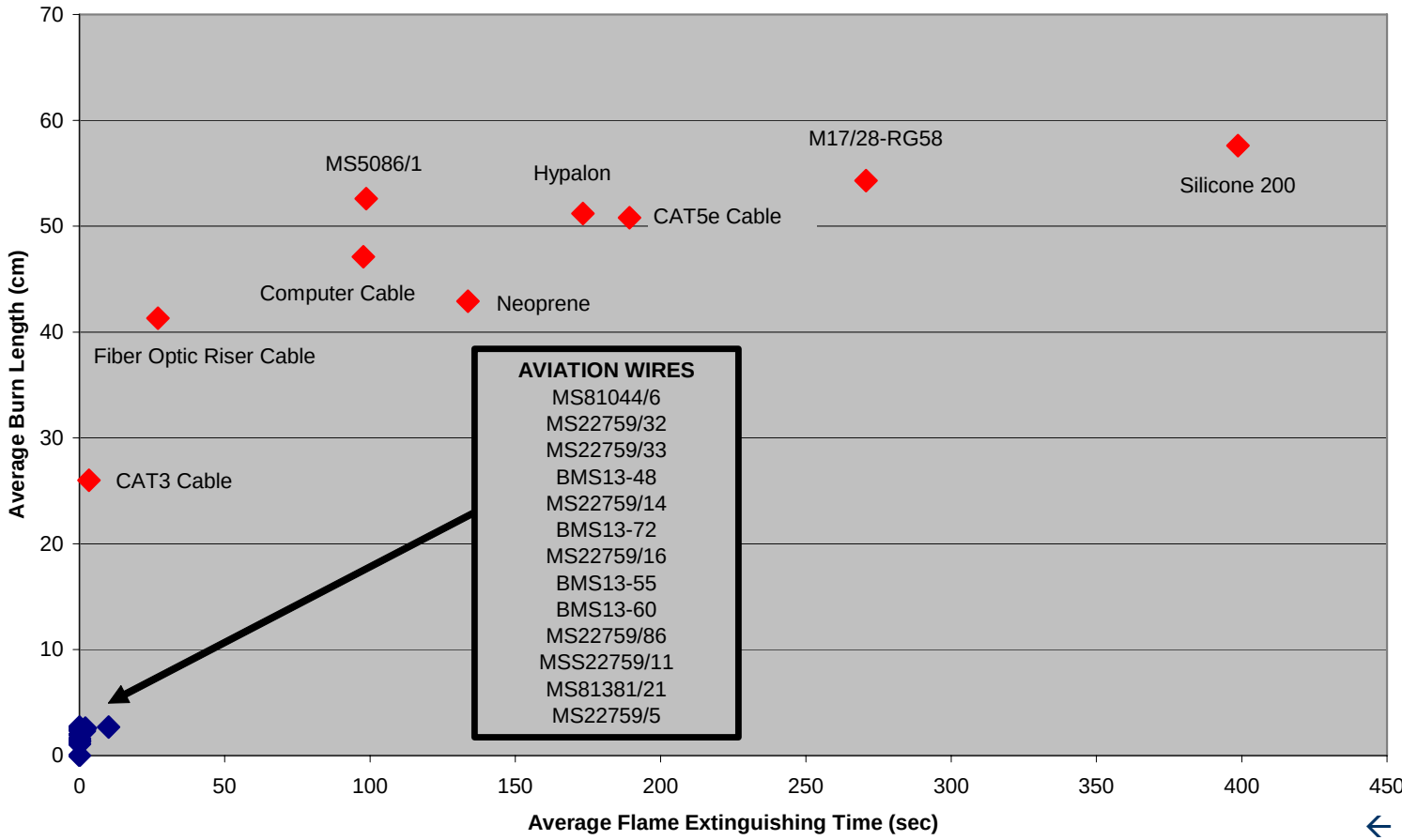


INTERMEDIATE-SCALE FIRE TEST OF WIRES/CABLES
(ISF Data versus RHP 30 Degree Test Data: 7.62 cm Distance, 1 min Exposure, 3 sec Pilot)



Execution Process: WBS 1.8

30 DEGREE RADIANT HEAT PANEL TEST FOR ELECTRICAL WIRES & CABLES
(Heat Flux: 1.7 W/cm2, Wires at 7.62 cm from the Panel, 1-minute Exposure, 3-seconds Pilot)



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Execution Process: WBS 1.8



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ISFT M17/28-RG58 (BL = 110 cm , FET = 1050 sec/17.5 min)

Execution Process: WBS 1.8



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RHPT M17/28-RG58 (BL = 56 cm , FET = 258 sec)

Execution Process: WBS 1.8



ISFT CAT3 Cable (BL = 97 cm , FET = 87 sec)

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Execution Process: WBS 1.8



RHPT CAT3 Cable (1.7W/cm2, 1-min Exposure, 3-sec Pilot, BL = 18 cm , FET = 3 sec)

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Execution Process: WBS 1.8



Correction:
Computer
Polypropylene
Cable

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ISFT Computer Cable (BL = 49 cm , FET = 196 sec)

Execution Process: WBS 1.8





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RHPT Computer Cable (1.7W/cm2 Radiant heat, 1 min exposure, 3 sec Pilot, BL = 47 cm , FET = 101 sec)

Execution Process: WBS 1.8

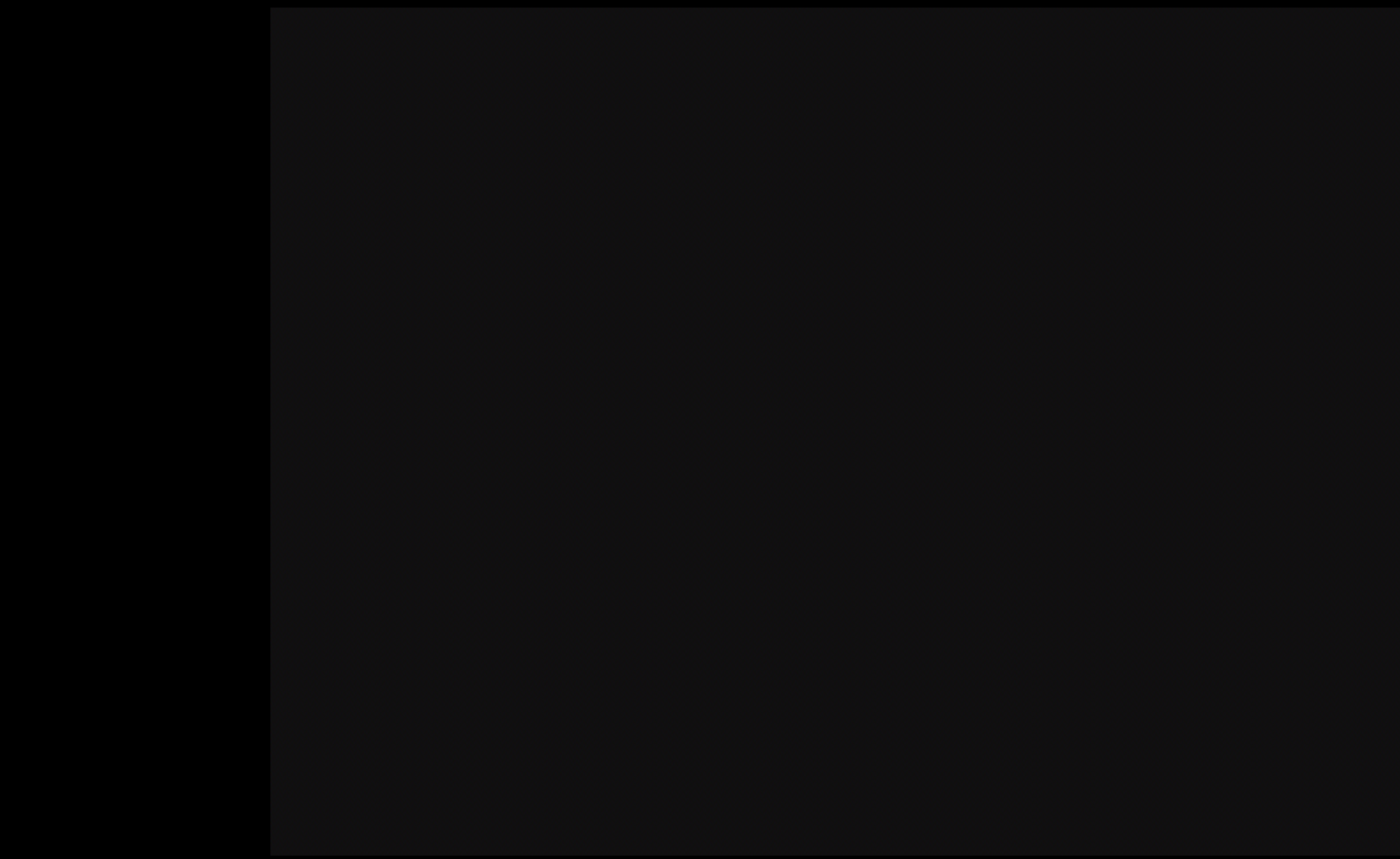


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ISFT MS22759/11 (BL = 33 cm , FET = 75 sec)

Execution Process: WBS 1.8



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RHPT MS22759/11 24 AWG (1.7W/cm2 Radiant heat, 1 min exposure, 3 sec Pilot, BL = 1.2 cm , FET = 0 sec)

Execution Process: WBS 1.8



Computer Cable Auto-igniting (1.7W/cm2 radiant heat, 1 min exposure)

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Execution Process: WBS 1.8



Infra-Red Video of Cable (1.7W/cm2, 1-minute Exposure, 15-sec Pilot)

Execution Process: WBS 1.8

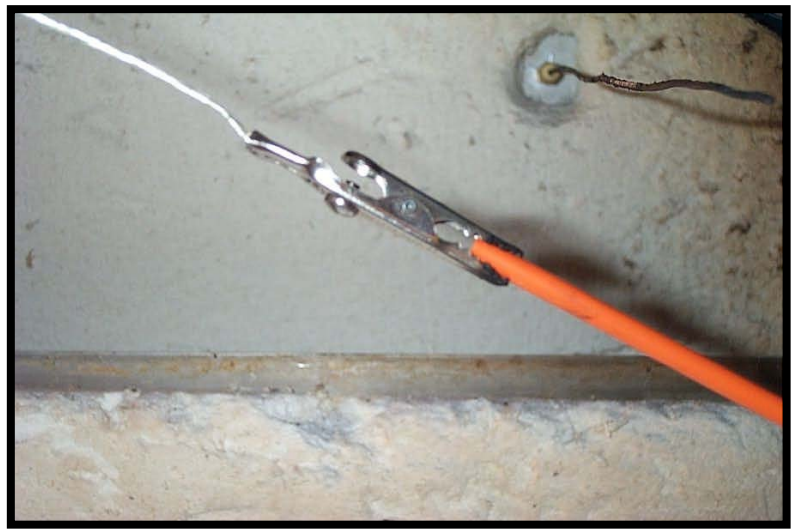


Infra-Red Video of Short Hypalon Wire (1.7W/cm2, 1-minute Exposure, 15-sec Pilot)

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Alligator Clip Technique to Hold Short Wire





A 12.5” short wire was tested in the 30 degrees test configuration to determine if there is a change in the performance of the insulation flammability in this configuration. There was no change in the flammability performance.

Execution Process: WBS 1.8



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RHP Test of Short Wire MS22759/32 (1.7W/cm2 radiant heat, 1 min exposure, 15-seconds Pilot)

Select/Modify Selected Test Method: Gradient



Marginal performing wire/cable samples were tested in this radiant heat gradient configuration. Results indicated that there was no correlation with the intermediate-scale test results. The poor performers did not fail this test.



Select/Modify Selected Test Method: Gradient

Item No.	Statistics Function	Material ID	Length (cm)	Flame Extinguishing Time (sec)	Burn Length (cm)	Initial Mass (g)	Final Mass (g)	Mass Loss (g)	Acceptance Criteria	Comments
1	Average	CAT3 Cable	31.75	2	4.9	N/A	N/A	N/A	Passed	Wire cut during test to fit in test fixture
	Std Dev		0	1	0.95	N/A	N/A	N/A		
2	Average	Fiber Optic Riser Cable	31.75	1.7	6.2	N/A	N/A	N/A	Passed	Wire cut during test to fit in test fixture
	Std Dev		0	0.6	0.9	N/A	N/A	N/A		
3	Average	Hypalon	31.75	289.3	25.6	N/A	N/A	N/A	Failed	Wire cut during test to fit in test fixture
	Std Dev		0	110.3	4.2	N/A	N/A	N/A		
4	Average	Mil17/28-RG58	31.75	259.5	28	N/A	N/A	N/A	Failed	Wire cut during test to fit in test fixture
	Std Dev		0	9.2	0.0	N/A	N/A	N/A		
5	Average	MS81044/6	31.75	1.3	2.3	2.8	2.8	0.1	Passed	
	Std Dev		0	1.2	0.3	0.0	0.0	0.0		

Execution Process: WBS 1.8



RHPT of CAT3 Cable, Gradient Setup (1.7W/cm2, 1-minute Exposure, 15-seconds Pilot)

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Execution Process: WBS 1.9

WBS 1.9 Verify Test Method

- **30-DEGREE RADIANT HEAT PANEL TEST FOR ELECTRIC WIRE**
  - To be recommended as replacement test to Chapter 4 in the *Aircraft Materials Fire Test Handbook* and 14 CFR Part 25 Appendix F, part I (1v) and (3)
  - **Sample Size:** 76.2 cm mounted at 30 degrees from horizon (smaller samples allowed with alligator clips).
  - **Heat Sources:** (1) Radiant Heat: 1.7W/cm^2, (2) Pilot Flame: Propane Flame (T>1093 C), perpendicular to wire sample
  - **Heat Source Exposure:** (1) Radiant Heat: 1 minute, (2) Pilot Flame: 3 seconds
  - **Flame Extinguishing Time:** <30 seconds
  - **Burn Length:** <7.6 cm
  - **Drip Extinguishing Time:** <3 sec



Execution Process: WBS 1.9

WBS 1.9 Verify Test Method (Cont.)

- Verified procedure with various wire gage sizes: 24 AWG, 20 AWG, and 10 AWG. Also tested jacketed cables.
- Will conduct Round-Robin exercise with other labs to verify procedures.



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