

Proposed Radiant Heat Panel Test

For the Evaluation of Aircraft Duct Material

“Status Report”

Presented to: International Aircraft Material Fire
Test Working Group

By: John Reinhardt, Aerospace Engineer

Date: December 6-7, 2006



Federal Aviation
Administration



Outline



Where are We?

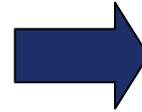
- ✓ Analyzed/compared IST data versus RHP data
- Modified RHP test settings to match IST results
- Conducted 12 radiant heat panel tests using new settings
- Conducted additional IST tests
- New Radiant Heat Panel Test
- Final Words



Analysis



Intermediate-Scale Test

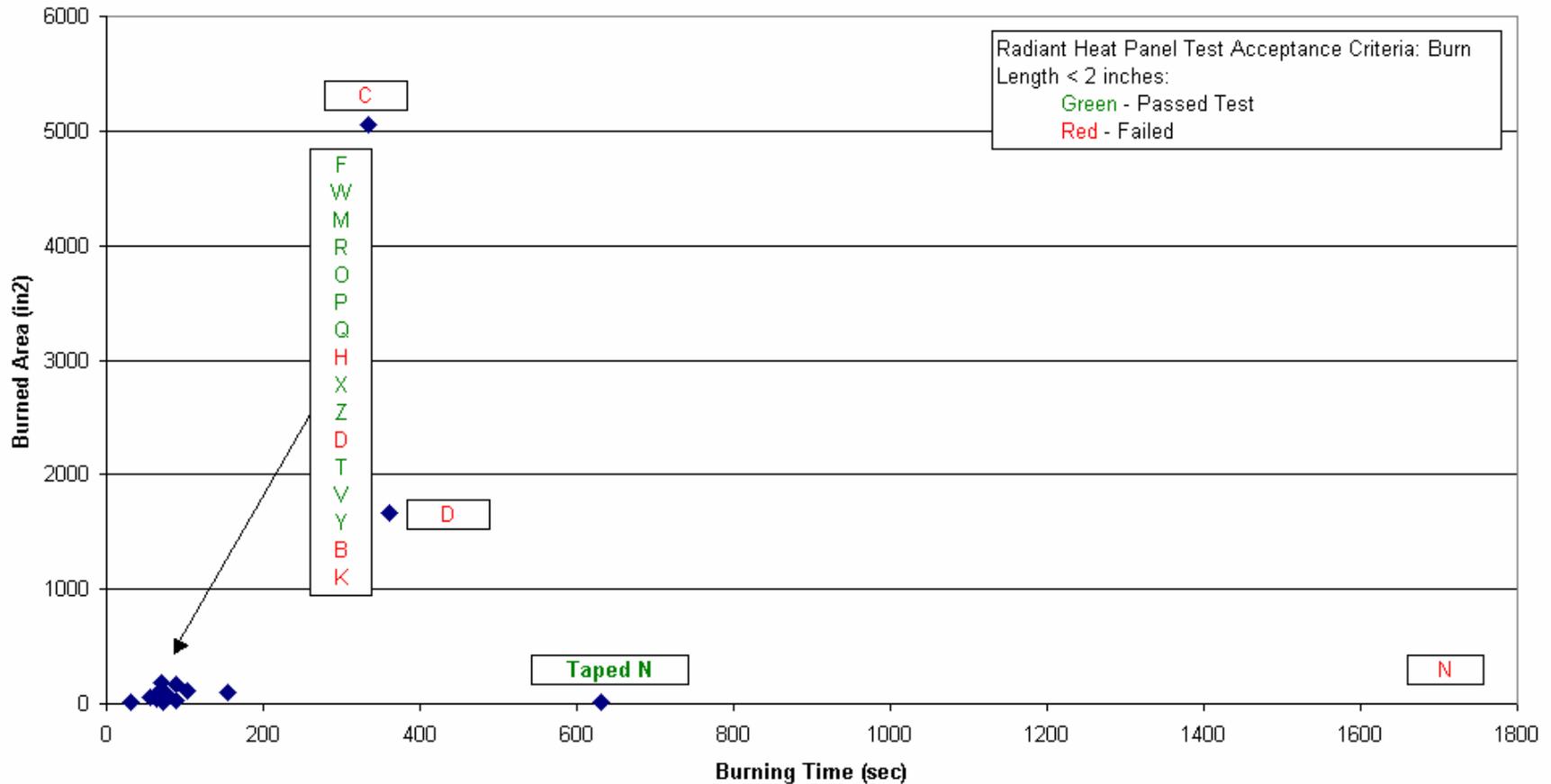


**Radiant Heat Panel Test
(Small-Scale Test)**

Analysis



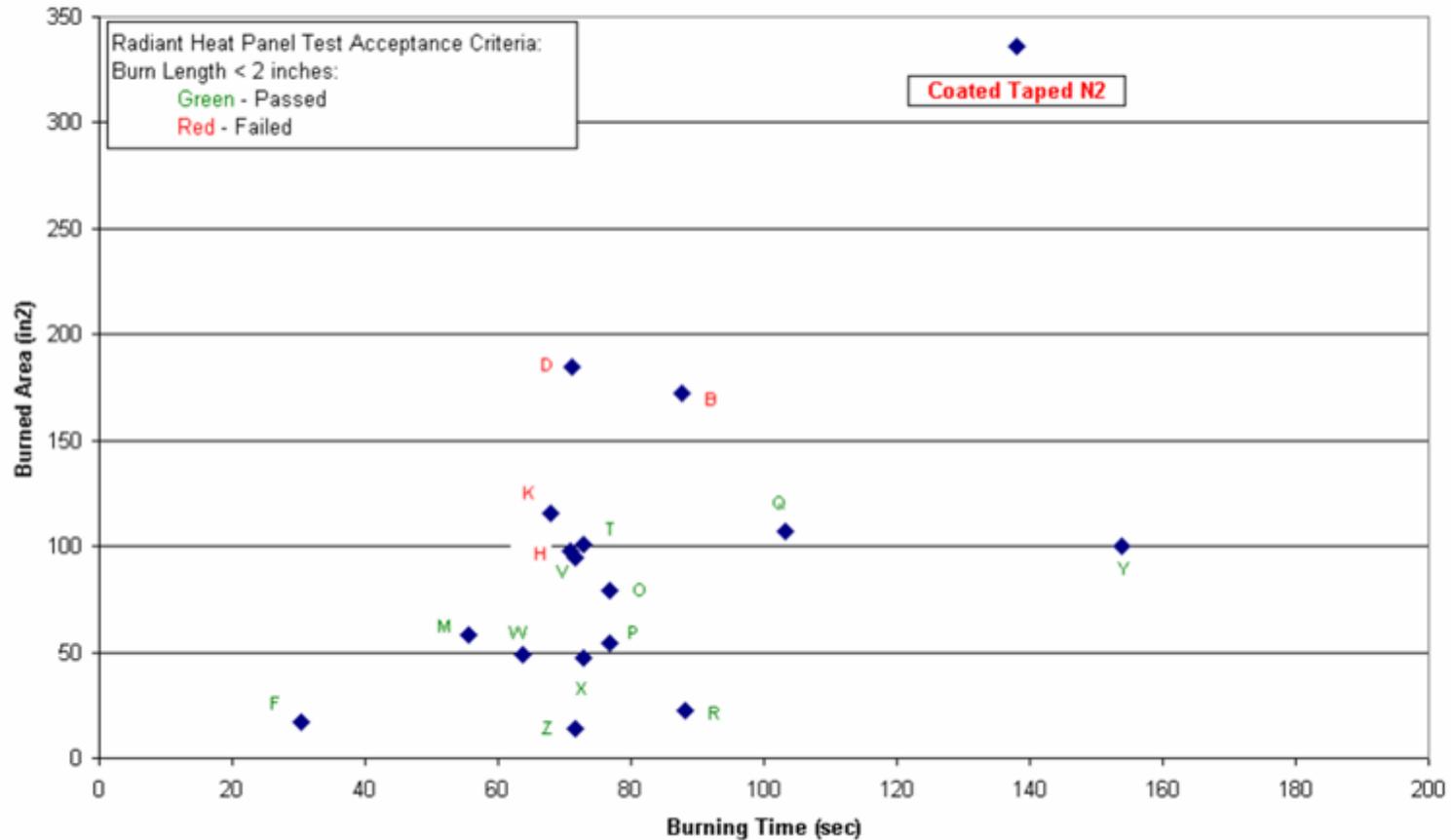
INTERMEDIATE-SCALE TEST Aircraft Ducting Materials



Analysis



INTERMEDIATE-SCALE TEST Aircraft Ducting Materials

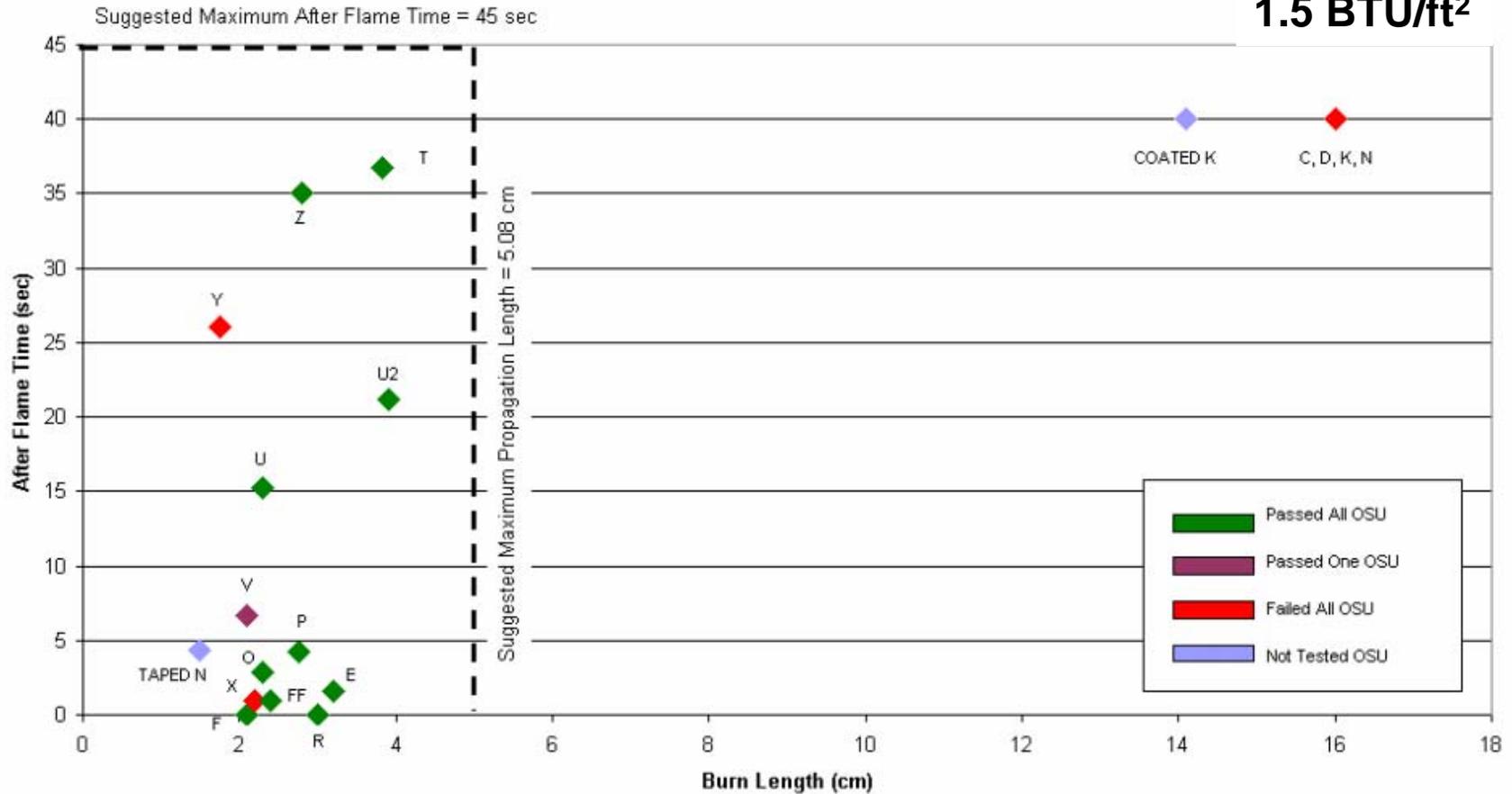


Analysis



EXPERIMENTAL RADIANT PANEL TEST RESULTS Aircraft Ducting Materials

1.5 BTU/ft²





COMPARISON BETWEEN IST & RHP TESTS

- Looking at the failed samples: C, K, Coated/Tape N, N & D



$T_i = 239\text{ }^\circ\text{C}$
IST Burning Time = 5.58 minutes
IST Burned Area = 32,583 cm²
IST Peak Temperature = 825 °C

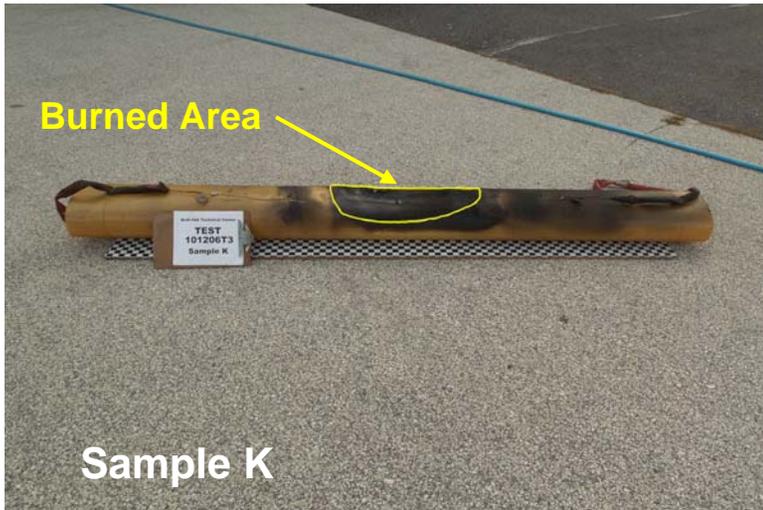


RP Burned Length = 16 cm
RP After Flame = >40 sec
OSU Peak Heat Released = 82.8 kW/m²
OSU Total Heat Released = 111.8 kW/m²
Smoke Density = 130.7



COMPARISON BETWEEN IST & RHP TESTS (CONT.)

- Looking at the failed samples: C, K, Coated/Tape N, N & D



$T_i = 322 \text{ }^\circ\text{C}$
IST Burning Time = 1.13 minutes
IST Burned Area = 750 cm^2
IST Peak Temperature = $896 \text{ }^\circ\text{C}$



RP Burned Length = 16 cm
RP After Flame = >40 sec
OSU Peak Heat Released = 70.5 kW/m^2
OSU Total Heat Released = 72.9 kW/m^2
Smoke Density = 189



COMPARISON BETWEEN IST & RHP TESTS (CONT.)

- Looking at the failed samples: C, K, Coated/Tape N, N & D



$T_i = \text{N/A}$
IST Burning Time = 40 minutes
IST Burned Area = 4985 cm²
IST Peak Temperature = 766 °C

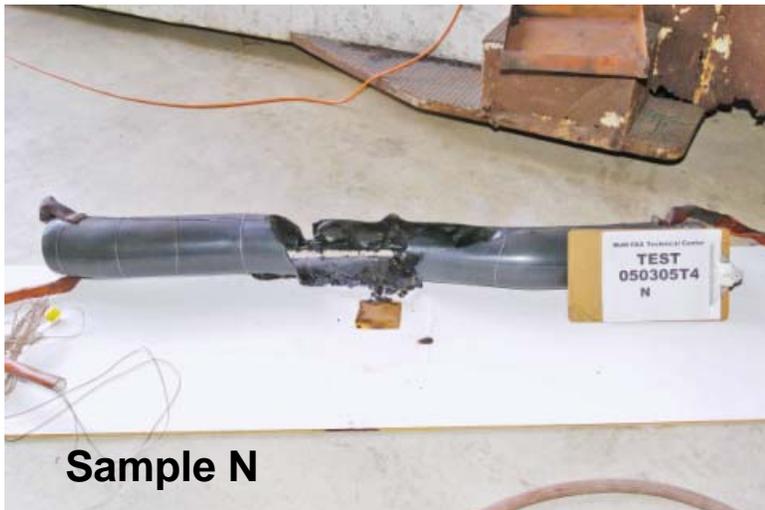


RP Burned Length = 9.7 cm
RP After Flame = >40 sec
OSU Peak Heat Released = N/A
OSU Total Heat Released = N/A
Smoke Density = N/A



COMPARISON BETWEEN IST & RHP TESTS (CONT.)

- Looking at the failed samples: C, K, Coated/Tape N, N & D



$T_i = 358 \text{ }^\circ\text{C}$
IST Burning Time = 30 minutes
IST Burned Area = 1752 cm^2
IST Peak Temperature = $708 \text{ }^\circ\text{C}$

RP Burned Length = 16 cm
RP After Flame = >40 sec
OSU Peak Heat Released = 179 kW/m^2
OSU Total Heat Released = 114 kW/m^2
Smoke Density = 176



COMPARISON BETWEEN IST & RHP TESTS (CONT.)

- Looking at the failed samples: C, K, Coated/Tape N, N & D



Sample D

$T_i = <300\text{ }^\circ\text{C}$
IST Burning Time = N/A minutes
IST Burned Area = N/A cm^2
IST Peak Temperature = N/A $^\circ\text{C}$



RP Burned Length = 16 cm
RP After Flame = >40 sec
OSU Peak Heat Released = 66 kW/m^2
OSU Total Heat Released = 30 kW/m^2
Smoke Density = 4.5



COMPARISON BETWEEN IST & RHP TESTS (CONT.)

- Ignition Temperatures of Failed Materials

Sample ID	Ignition Temp (degC)	Heat Release (W/g)
C	239	436
K	322	120
N	358	599
D*	486	21

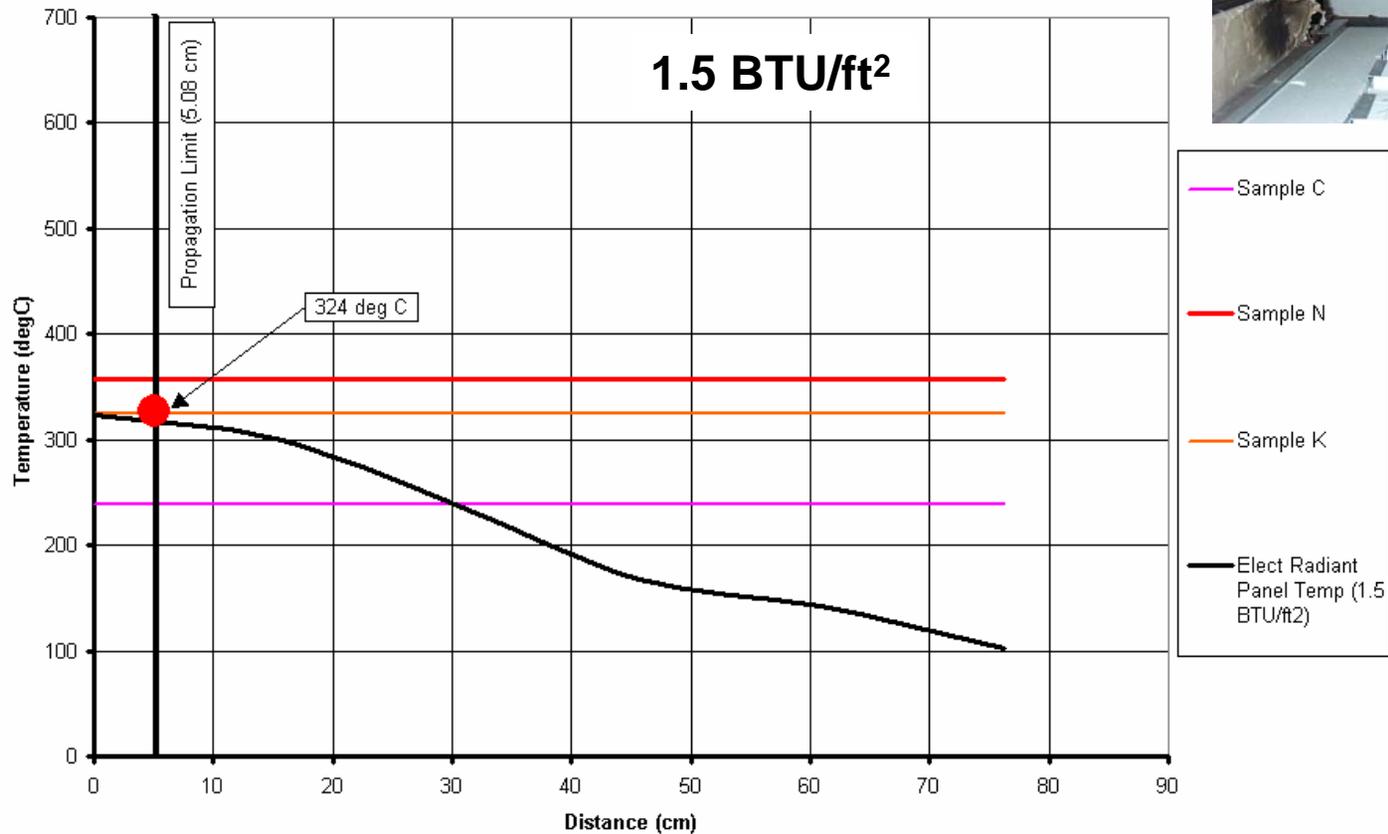
*Note: Combustion reaction observed on Sample D after reaching 175 degC. Information about the coated/taped N is not available

Analysis



COMPARISON BETWEEN IST & RHP TESTS (CONT.)

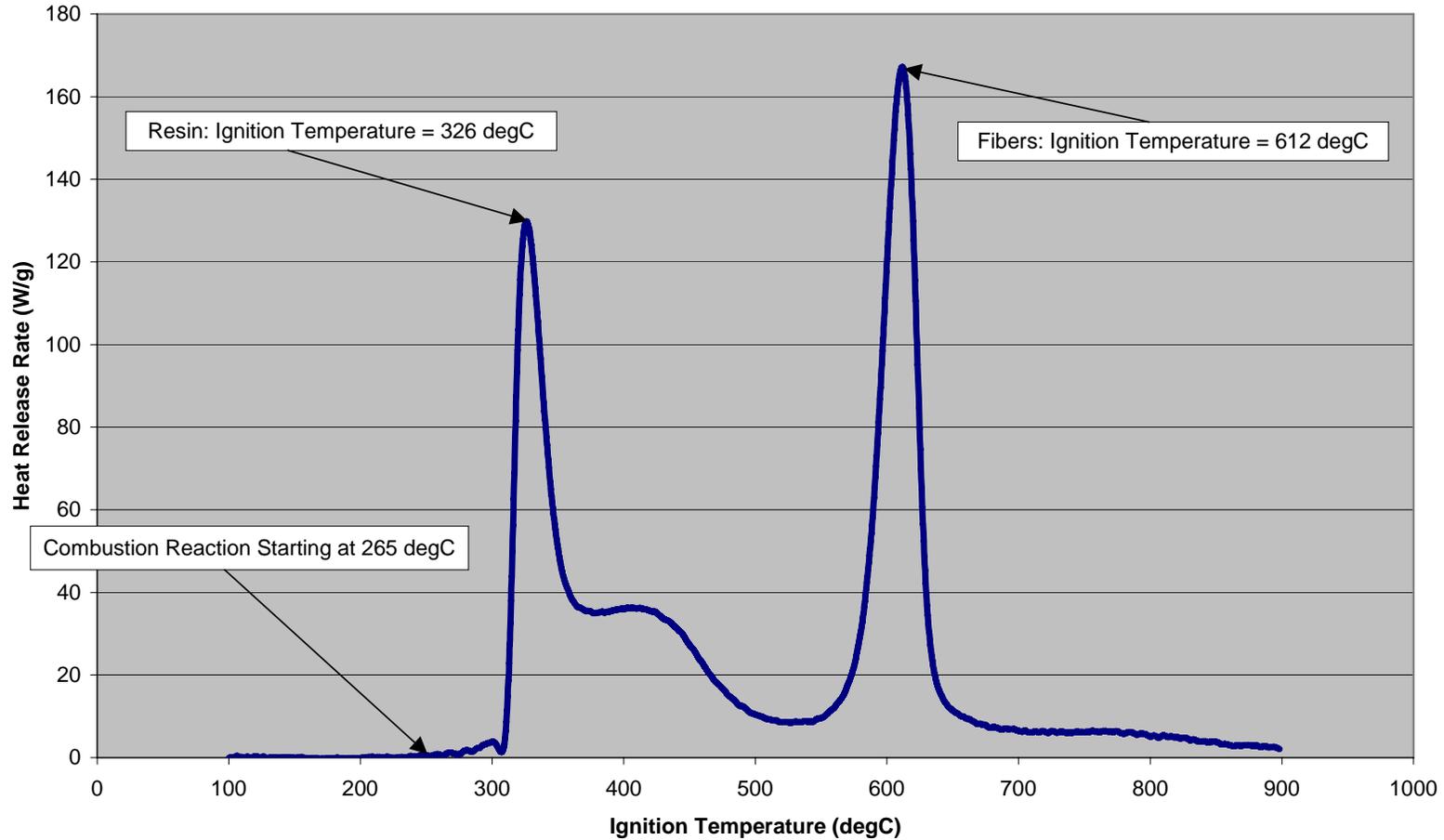
RADIANT PANEL TEMPERATURE PROFILE VS SAMPLE IGNITION TEMPERATURE



Analysis



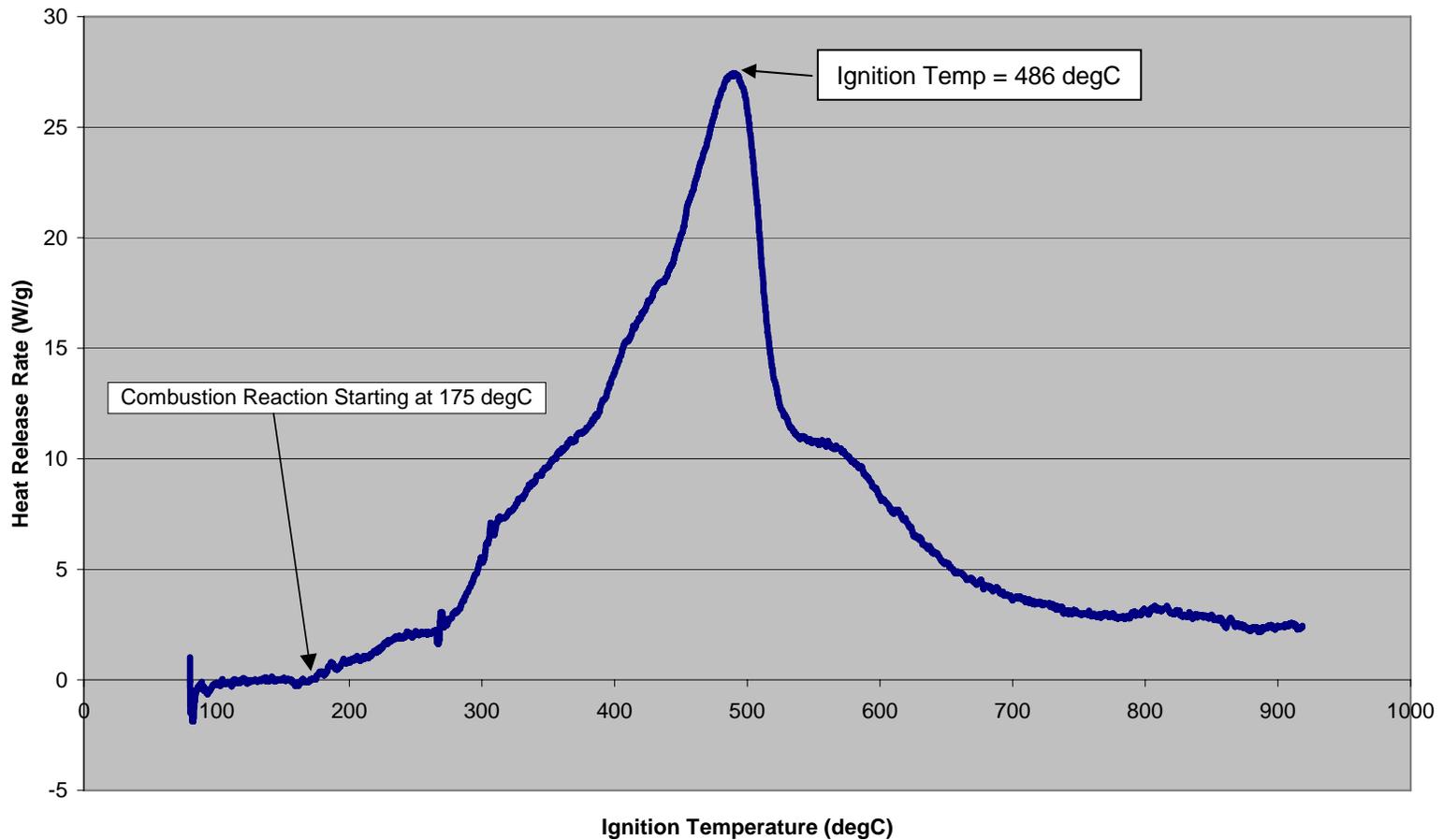
Micro-Scale Combustion Calorimeter Test
Sample K



Analysis



Micro-Scale Combustion Calorimeter Test
Sample D





COMPARISON BETWEEN IST & RHP TESTS (CONT.)

- For this application, the temperature of the radiant heat panel is higher than the ignition temperature of samples C and K.
- **HYPOTHESIS:**
 - ✓ The temperature of the radiant heat panel has to be decreased in order for Sample K to pass the RHP test.
 - This decrease in the radiant heat panel temperature may not affect the results of samples C & N (and coated/taped N) since these samples release a significant amount of heat that promotes self-combustion.
 - It is expected that sample D will also fail since a combustion reaction was noticed at about 175 degC during MSCC test.
- Therefore, RHP testing, with new settings, must be conducted to check hypothesis.

Aircraft HVAC Duct Test



Where are We?

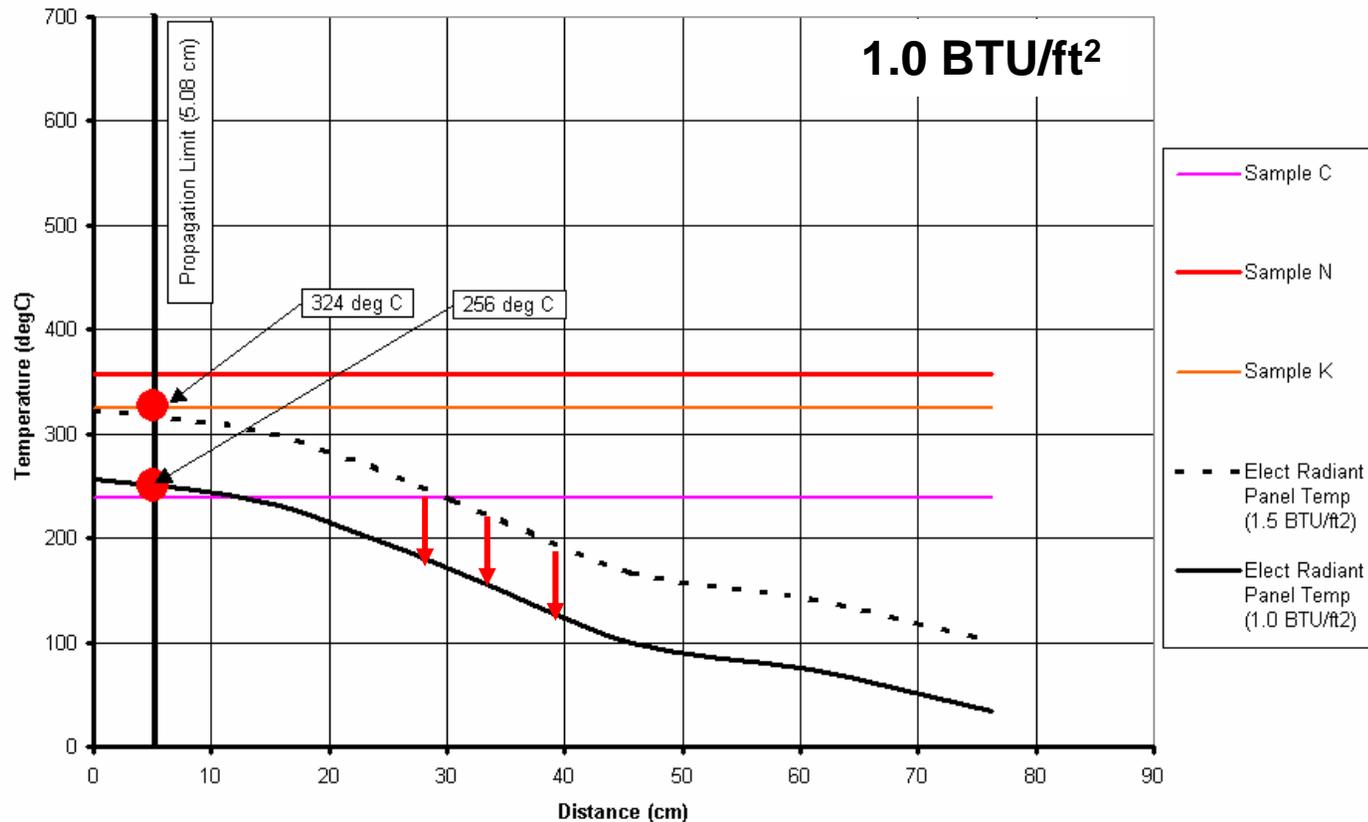
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Analysis



RADIANT PANEL TEMPERATURE PROFILE VS SAMPLE IGNITION TEMPERATURE



Outline



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1 BTU/ft² Radiant Heat Panel Tests



Tested:

- | | |
|--------------|--------------|
| 1. Sample AW | 7. Sample K |
| 2. Sample B | 8. Sample N |
| 3. Sample C | 8. Sample U |
| 4. Sample D | 10. Sample X |
| 5. Sample E | 11. Sample Y |
| 6. Sample H | 12. Sample Z |

1 BTU/ft² Radiant Heat Panel Tests



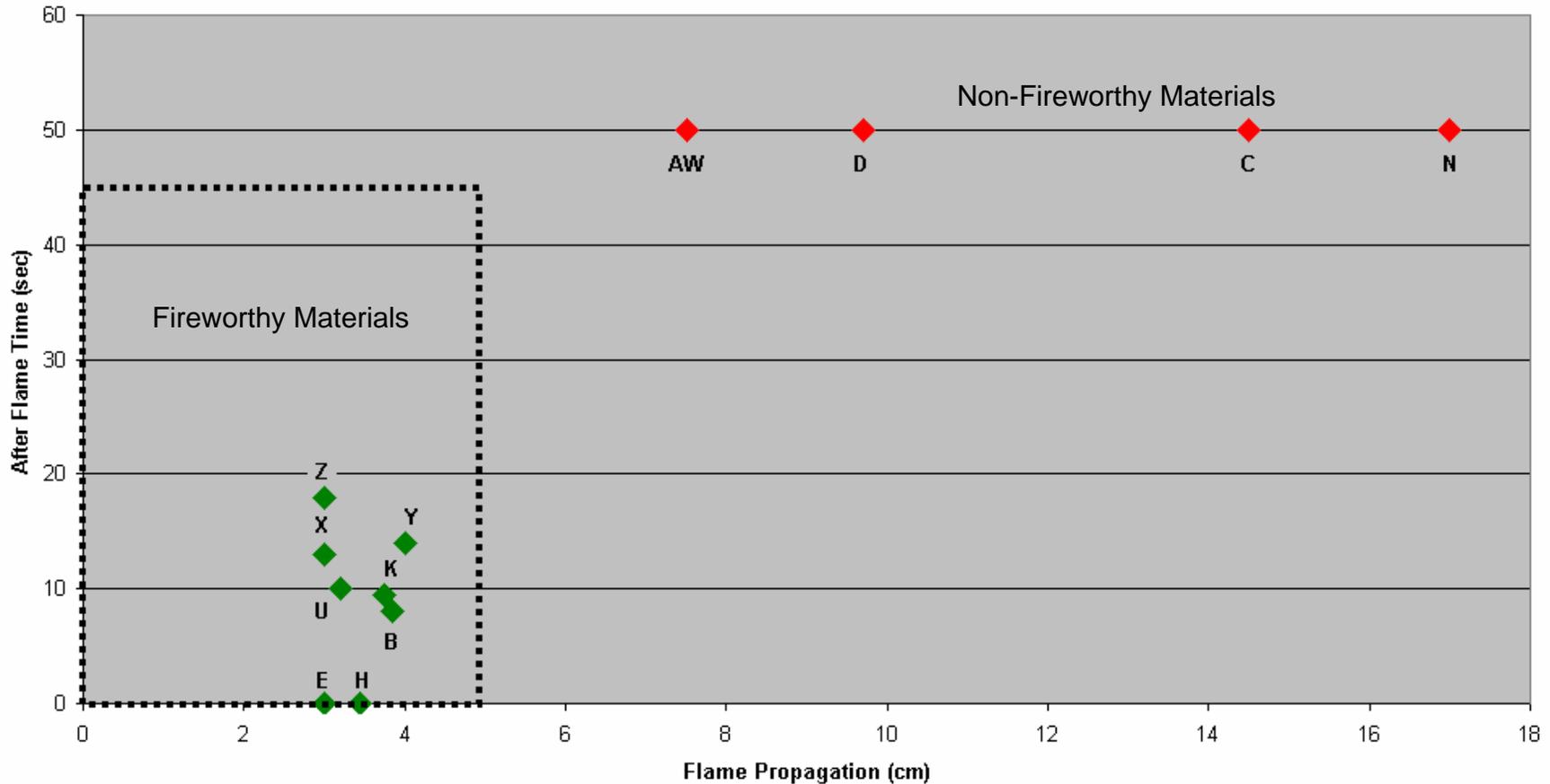
Results (1 BTU/ft² Test Protocol):

MATERIAL	RPHT FLAME PROPAGATION (cm)	FAA ACCEPTANCE CRITERIA (cm)	AFTER FLAME TIME (Sec)	FAA ACCEPTANCE CRITERIA (Sec)	PASS/ FAIL	COMMENTS
AW	7.5	5.08	50.0	45	Failed	
B	3.9	5.08	8.0	45	Passed	
C	14.5	5.08	50.0	45	Failed	
D	9.7	5.08	50.0	45	Failed	
E	3.0	5.08	0.0	45	Passed	
H	3.5	5.08	0.0	45	Passed	
K	3.8	5.08	9.5	45	Passed	Taped N
N	17.0	5.08	50.0	45	Failed	
U	3.2	5.08	10.0	45	Passed	
X	3.0	5.08	13.0	45	Passed	
Y	4.0	5.08	14.0	45	Passed	
Z	3.0	5.08	18.0	45	Passed	

1 BTU/ft² Radiant Heat Panel Tests



AIRCRAFT DUCTING RADIANT HEAT PANEL TEST RESULTS
1 BTU/FT² Heat for 1 Minute, Pilot Exposure: 15 seconds



Results Analysis



Sample AW

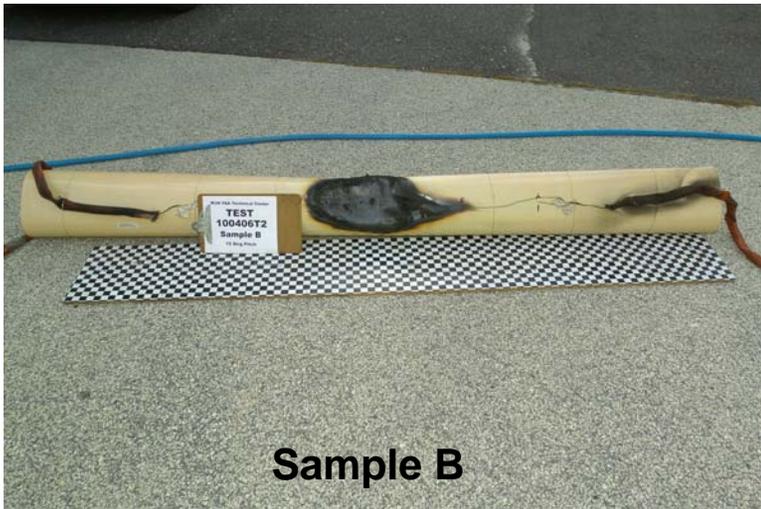


Tested at 1BTU/ft² Radiant Heat

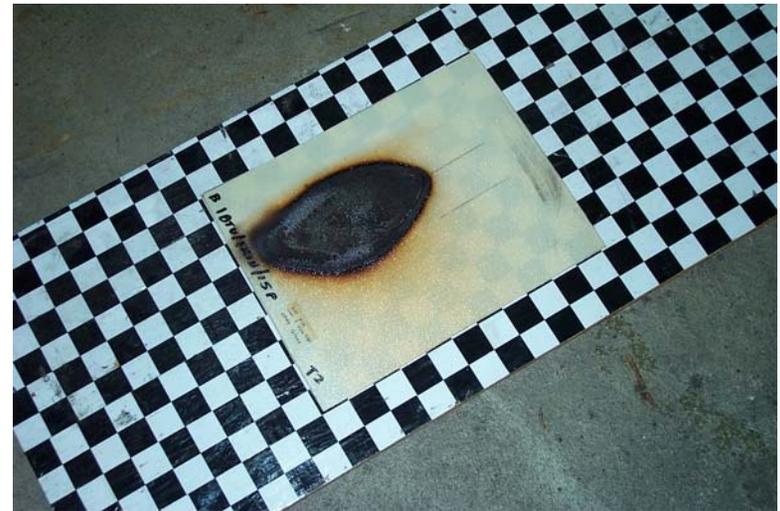
$T_i = 488\text{ }^{\circ}\text{C}$
HRR = 427 W/g
IST Burning Time = 8.5 minutes
IST Burned Length = 64.8 cm
IST Peak Temperature = 1409 $^{\circ}\text{C}$
IST Peak Heat Release Rate = 64 kW/m²

RHP Burn Length = 7.5 cm
RHP After Flame Time > 50 minutes

Results Analysis



Sample B



Tested at 1BTU/ft² Radiant Heat

Results Analysis



Results Analysis

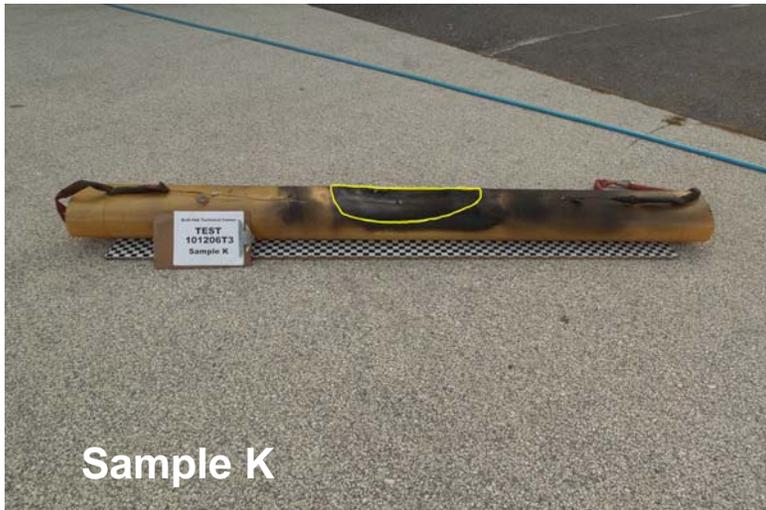


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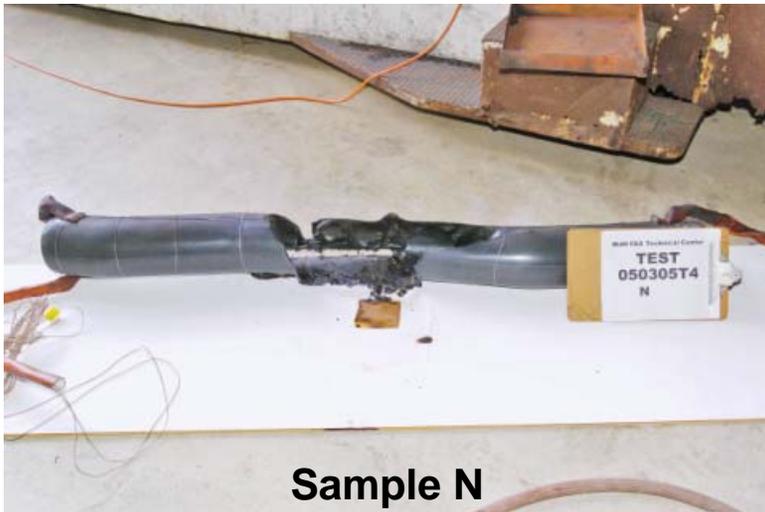
Tested at 1BTU/ft² Radiant Heat

Results Analysis



Tested at 1BTU/ft² Radiant Heat

Results Analysis



Results Analysis

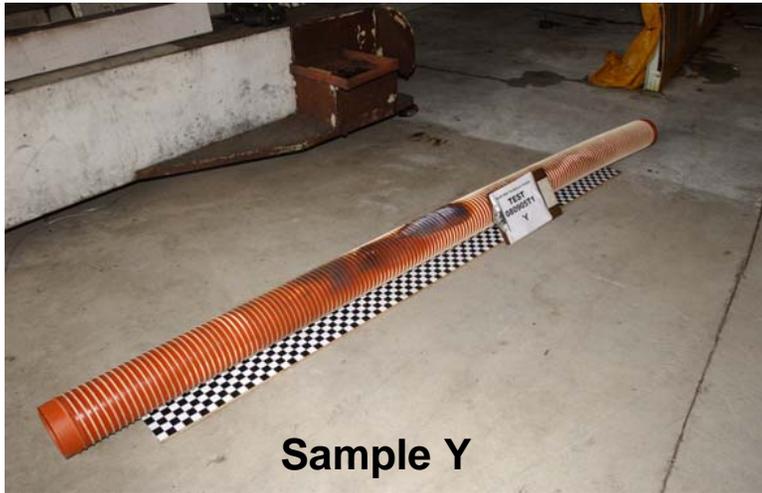


Sample X



Tested at 1BTU/ft² Radiant Heat

Results Analysis



Sample Y



Tested at 1BTU/ft² Radiant Heat

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- Final Words



Additional IST Tests



$T_i = 581\text{ }^{\circ}\text{C}$
IST Burning Time = 4.48 minutes
IST Burned Length = 39.4 cm
IST Peak Temperature = 1425 $^{\circ}\text{C}$

Outline



Where are We?

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- Modified RHP test settings to match IST results
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- Conducted additional IST tests
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- Final Words



Radiant Heat Panel Test Protocol



EQUIPMENT:



Vertical Bunsen Burner Test Apparatus
(FAR 25.853 or Handbook)

Radiant Heat Panel Test Apparatus
(FAR 25.856)

Radiant Heat Panel Test Protocol

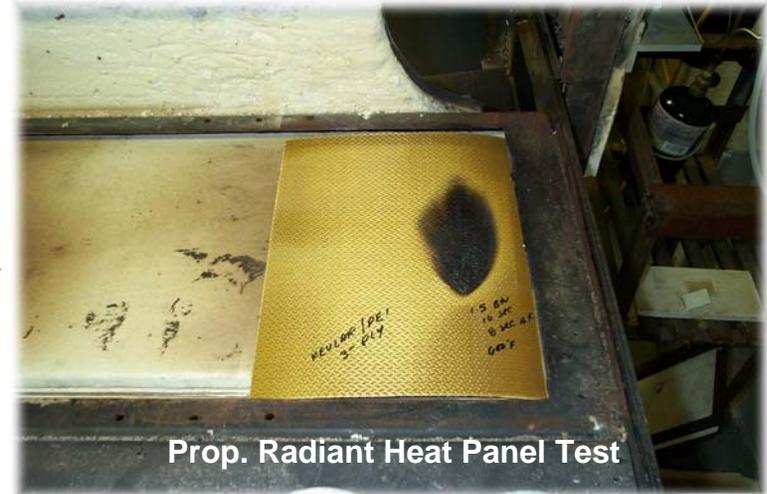


SPECIMEN:



Vertical Bunsen Burner Test

- 2.75" x 12" (unless actual size smaller)
- Test maximum and minimum thickness
- If thickness > 0.5", test material at 0.5"
- Test flat sheet ($t < 0.125$ ") if sample smaller than size of specimen



Prop. Radiant Heat Panel Test

- 8.5" x 11" (unless actual size smaller)
- Test maximum and minimum thickness
- If thickness > 0.5", test material at 0.5"
- Test flat sheet ($t < 0.125$ ") if sample smaller than size of specimen
- Fire Blocking Jacket, hook & loop, tapes, etc.

Radiant Heat Panel Test Protocol

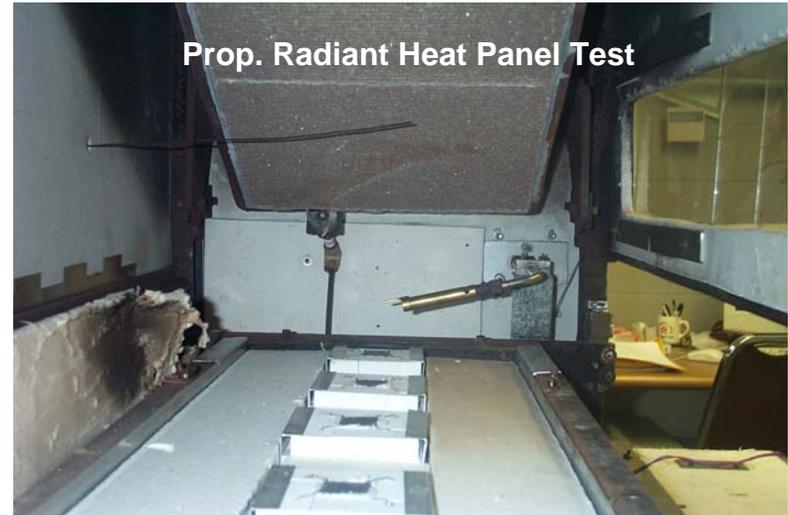


FIRE THREAT:



Vertical Bunsen
Burner Test

- Methane Pilot Flame (Inner cone = 7/8" & tip of flame = 1.5 in)



Prop. Radiant Heat Panel Test

- 1 BTU/ft² Radiant Heat (1 min Exposure)
- Propane Pilot Flame (blue inner cone = 3/4", overall flame length = 5" long)

Radiant Heat Panel Test Protocol



TEST PROCEDURE:



Vertical Bunsen Burner Test

- Impinge the pilot burner flame on the sample for 12 seconds
- Maintain sample in chamber until flames are self-extinguished or after flame time > 15 seconds
- Record after flame time, burn length, and drip flame time



Prop. Radiant Heat Panel Test

- Expose sample to 1 BTU/ft² radiant heat for 1 minute
- After the 1 minute exposure, impinge the pilot burner flame on the sample for 15 seconds
- Maintain sample in chamber until flames are self-extinguished or after flame time > 45 seconds
- Record after flame time and burn length

Radiant Heat Panel Test Protocol



ACCEPTANCE CRITERIA

Vertical Bunsen Burner Test

- Burn Length $\leq 8''$
- Flame Time ≤ 15 sec
- Drip Flame Time ≤ 3 sec



Radiant Heat Panel Test

- Burn Length $\leq 2''$
- After Flame Time ≤ 45 sec
- Fire Blocking Jacket, tapes or hook and loop shall not shrink away

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Final Words



What's Next?

- Conduct additional tests as needed
- Prepare final report
- Submit final report to FAA Internal Sponsor



Final Words



Questions?

