Vertical Bunsen Burner Test

The Evaluation of the 12-seconds Vertical Bunsen Burner Test Appendix F Part I(a)(4) to Part 25




INTERNATIONAL AIRCRAFT MATERIALS FIRE TEST WORKING GROUP
ATLANTA, GEORGIA OCTOBER 19-20, 2005 MEETING
WJH FAA Technical Center
John W. Reinhardt
Fire Safety Section, AAR-422 Atlantic City Int'l Airport, New Jersey 08405

Outline

TOPICS

- Project Objectives
- Brief Overview (London Meeting)
- Answer to Previous TG Questions
- Discuss Tests Result Data
- Discuss Intermediate-Scale Test vs Radiant Panel Test

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Objective

OBJECTIVES

- FAA's goal is to raise the standard for the airplane such that fires in inaccessible areas do not spread and create catastrophic conditions.
- For ducts, the current test does not predict the behavior of the part in actual conditions and therefore suggests the need for a new standard.

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Overview

BRIEF OVERVIEW

During our last meeting in Gatwick, UK (June 28-29, 2005) the following was discussed:

- The fire test results of some (10) aircraft duct materials were presented.
- An approach to a new fire test protocol (based on the current FAA radiant panel test) was presented as a possible means of compliance to current regulations.
- First task group meeting was conducted.
- All of the task group members agreed that the 12-seconds vertical Bunsen burner test is not a good discriminator to determine the fireworthiness of a material.
- A couple of members did not agree that the current FAR test protocol should be evaluated under the current venue (recommended use of ARAC Committee).

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PREVIOUS TASK GROUP MEMBERS QUESTIONS

Q1. *"But, as an industry task group member, it is not clear to me that there has been enough industry discussion about the need for a new test requirement that takes into account in-service history relative to ducting."*

A1: As mentioned in the Objective section, the current FAA's mission is to raise the standard for the airplane such that fires in inaccessible areas do not spread and create catastrophic conditions. During the evaluation of the current test protocol for aircraft ducting, it was determined that this existing test is not up to par with the FAA's mission (Internal Deficiency). The FAA safety strategy today is to be proactive rather than reactive as in the past.

Q&A

Accident Date: 9/5/96, Location: Newburgh, New York Operator: Federal Express, Cause: Unknown Fire Source in Cargo

Q&A

Accident Date: 9/4/93, Location: Santo Domingo, Dominican Republic Operator: Dominicana, Cause: Unknown Fire aft of lavatory

PREVIOUS TASK GROUP MEMBERS QUESTIONS (CONT.)

Q2: *"Prioritization of this effort relative to other safety improvements should also be discussed, particularly with FAR 25.856(a) [Thermal/Acoustic Insulation Materials] now in effect."*

A2: When compared to FAR 25.856(a), this is a low priority project.

PREVIOUS TASK GROUP MEMBERS QUESTIONS (CONT.)

Q3: *"Having well defined goals along with the supporting rationale will provide a fundamental basis for the Ducting Task Group activities."*

A3: Ducting components are major parts in the aircraft, running in the attic, cheek, cargo compartments, and other areas, that have the probability of becoming a fuel source during a fire. Since this ducting system interconnects along the aircraft, it may provide a propagation path to the fire. To evaluate the propagation characteristic of a ducting material, the FAA requires that it be tested according to Appendix F to Part 25, Part I (a) (ii). After re-evaluating the Appendix F test, commonly known as the 12-seconds Vertical Bunsen Burner, results show that this test does not predict the behavior of the part in actual conditions and therefore suggests the need for a new test standard.

Q&A

12-sec Vertical Bunsen Burner Test

Intermediate-Scale Test

Outline

TOPICS

- Project Objectives
- Brief Overview (London Meeting)
- Answer to Previous TG Questions
- Discuss Tests Result Data
- Discuss Intermediate-Scale Test vs Radiant Panel Test

Results

TESTS RESULT DATA

12 & 60-Sec Vertical Bunsen Burner Test

Intermediate-Scale Test

Radiant Panel Test

OSU Heat Release Test

NBS Smoke Test

Micro-Scale Combustion Calorimeter Test

Results

TESTS RESULT DATA (CONT.)

- About 33 different types of specimens were donated by the working group members and tested by the FAATC (included different materials, shapes, configuration, thickness)
  - Rigid Ducts
  - Flexible Ducts
  - Thermoplastic & Thermosetting Composites
  - Old and New Materials Used for Aircraft Ducting
- More than 550 tests were conducted

Results

12 & 60 SECONDS VERTICAL BUNSEN BURNER TESTS:

Test Protocol: Chapter 1 of DOT/FAA/CT-89/15 Aircraft Material Fire Test Handbook

Sample Size: 75mm x 305mm

Heat Source: Methane Flame (41 kW/m^2, 925 ºC)

Heat Source Exposure: 12 (60) seconds

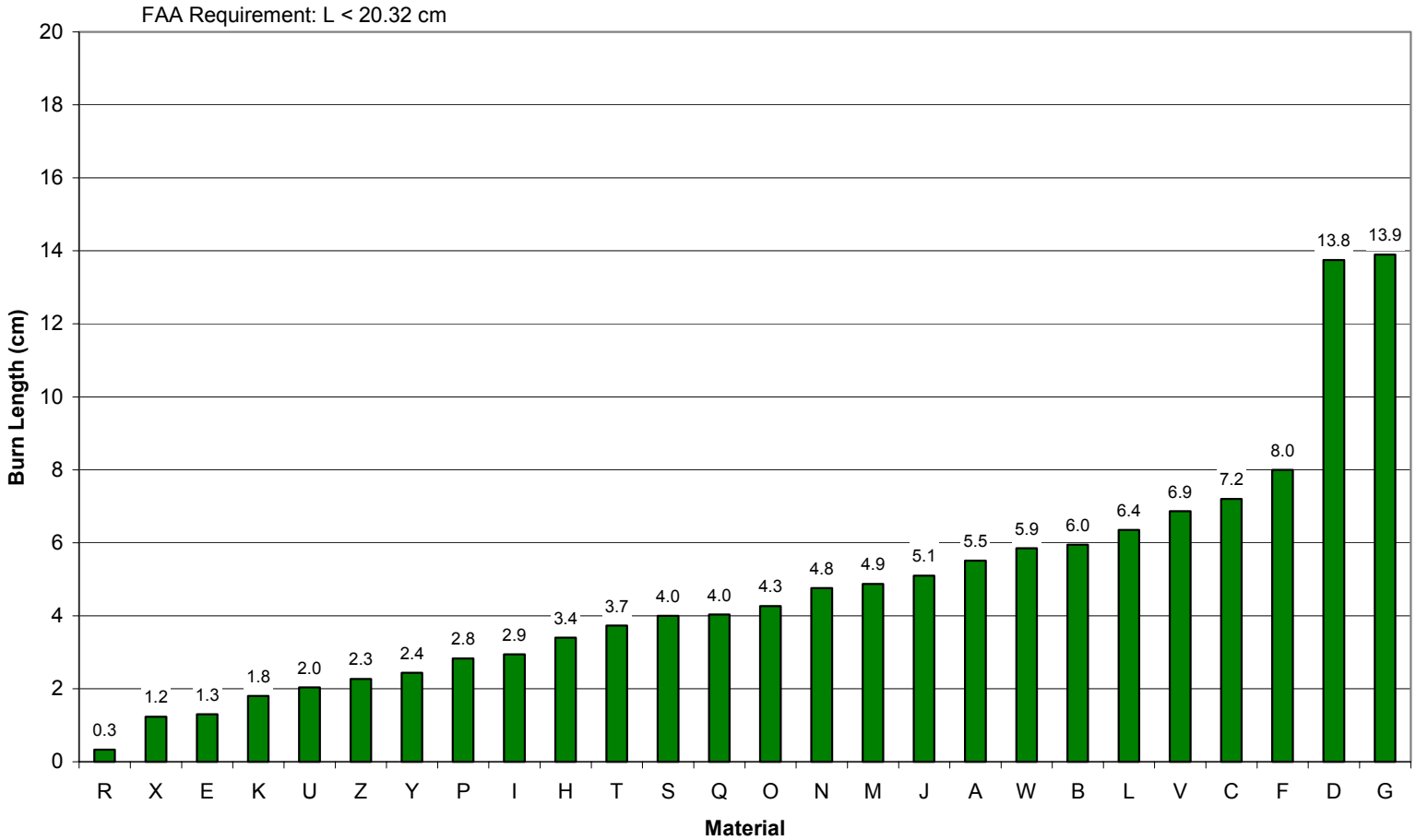
Flame Extinguishing Time: <15 seconds

Burn Length: <20.32cm (<15 cm)

Drip Extinguishing Time: <5 seconds

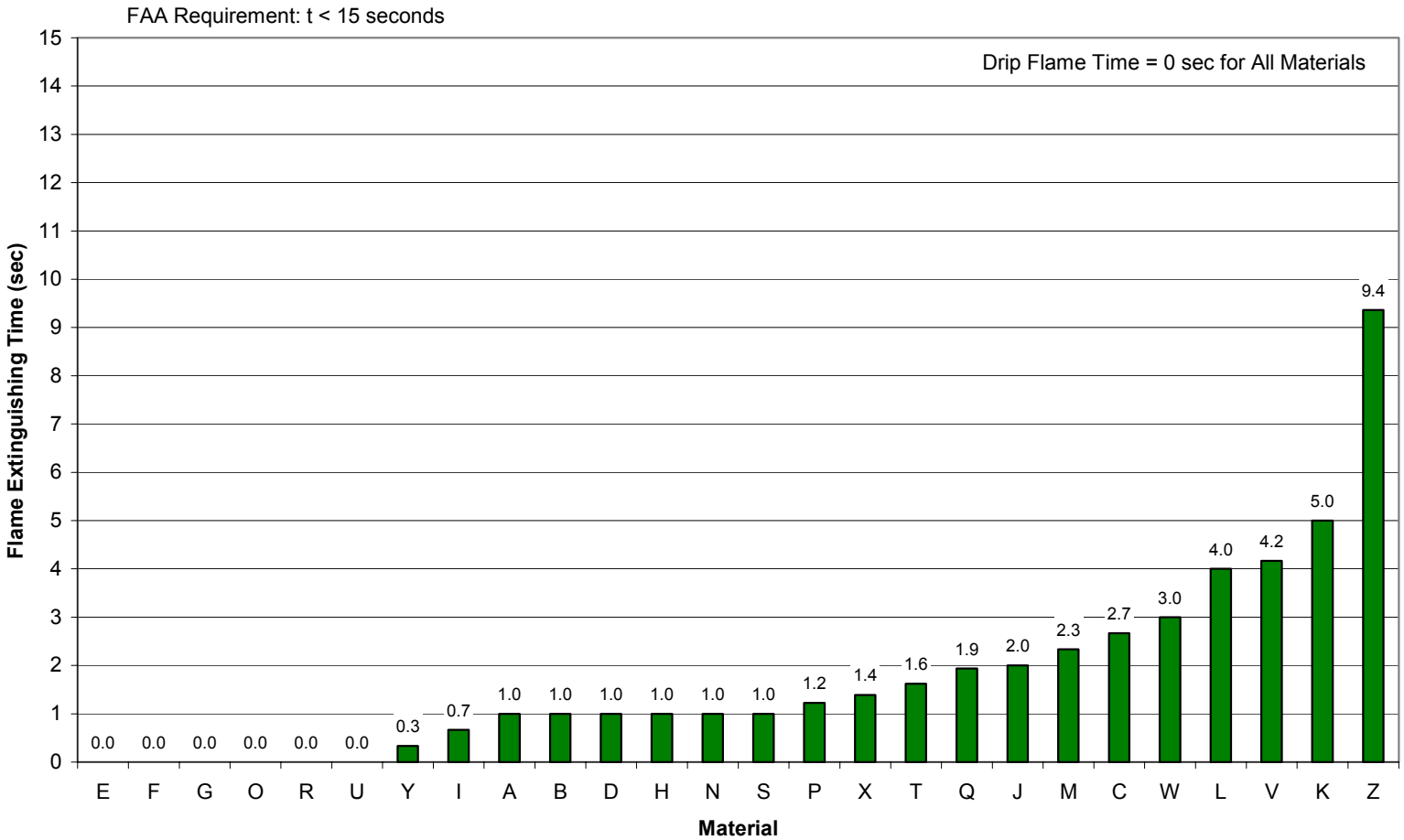
Results

12-SECONDS VERTICAL BUNSEN BURNER TEST
Aircraft Ducting Materials



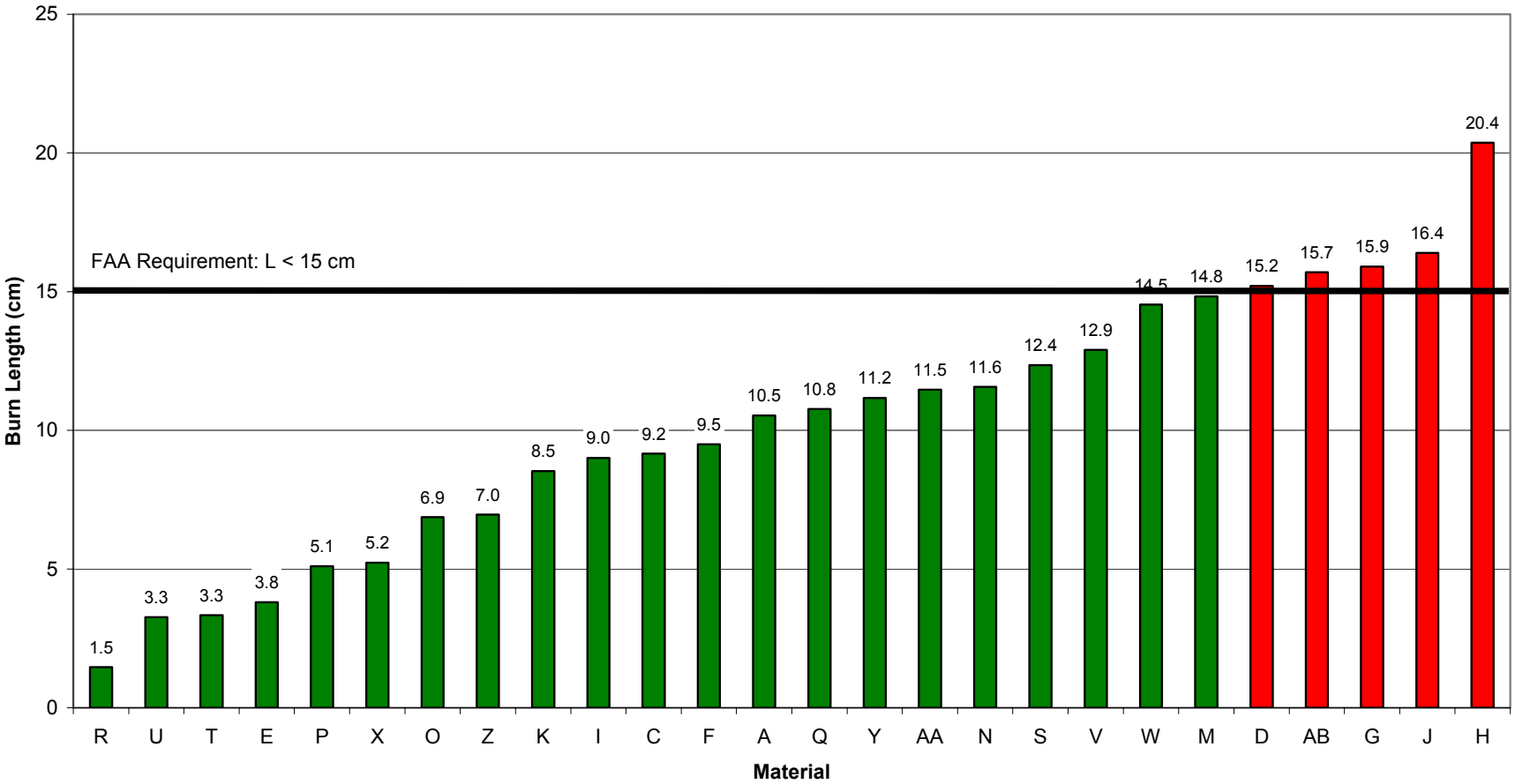
Results

12-SECONDS VERTICAL BUNSEN BURNER TEST
Aircraft Ducting Materials



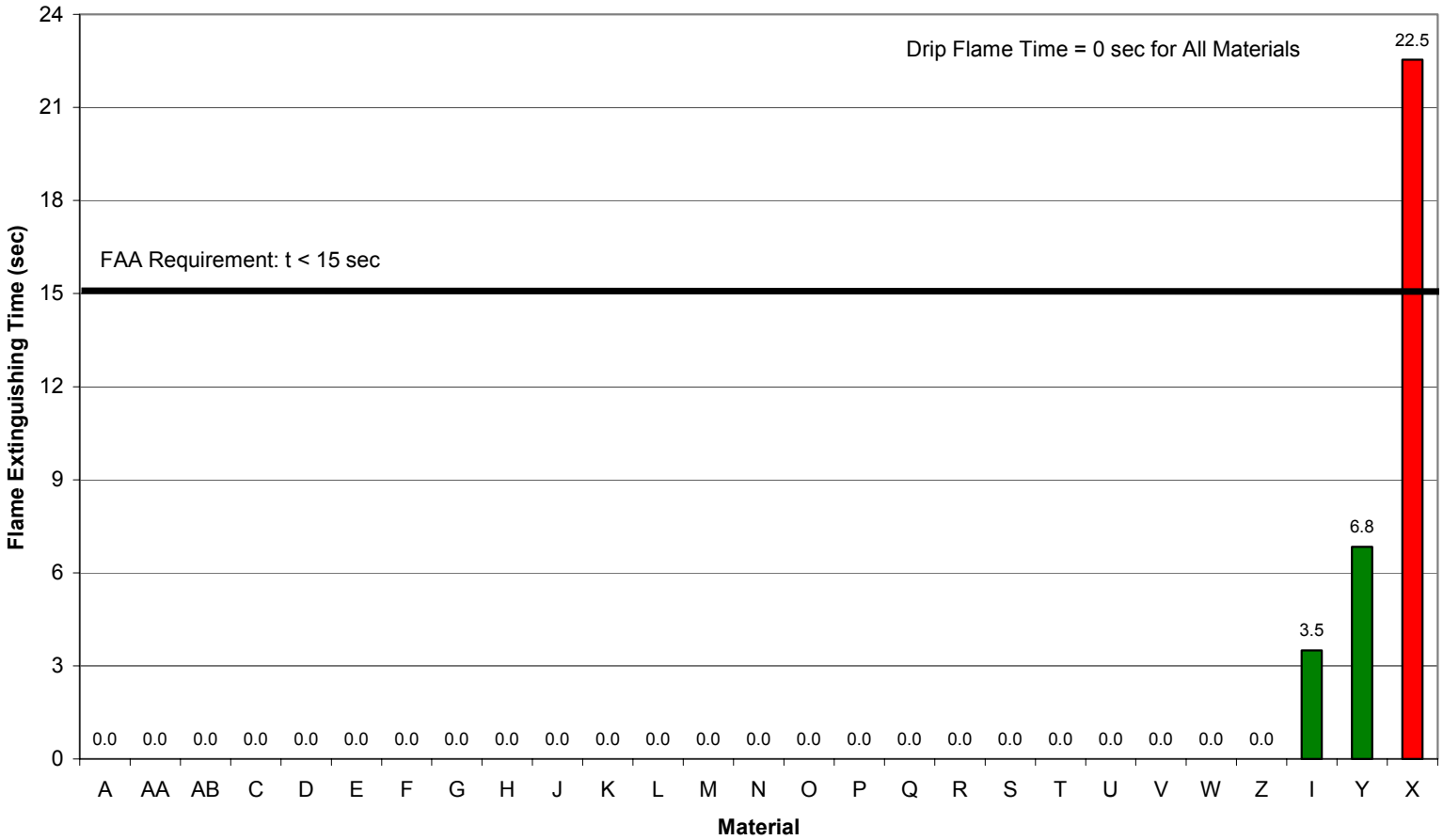
Results

60-SECONDS VERTICAL BUNSEN BURNER TEST
Aircraft Ducting Materials



Results

60-SECONDS VERTICAL BUNSEN BURNER TEST
Aircraft Ducting Materials



Results

INTERMEDIATE-SCALE FIRE TEST:

Test Protocol: FAA Report DOT/FAA/AR-99/44 - Dev. Of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation

Sample Size: 15.2cm (30.4cm) x 243.8cm

Heat Source: Polyurethane Foam Block (49 kW/m^2, 781 ºC)

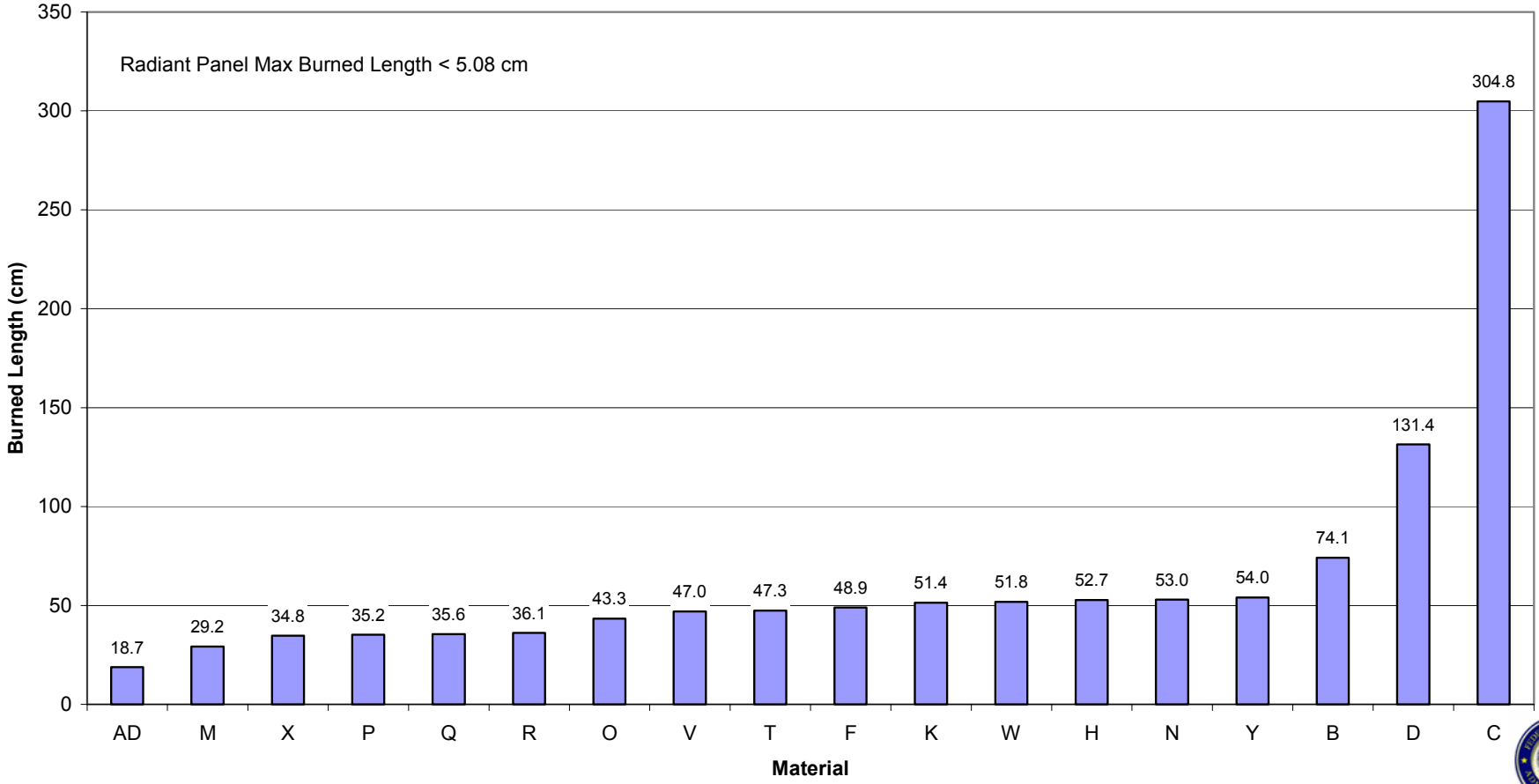
Heat Source Exposure: ~6 minutes

Not a compliance test

Results

INTERMEDIATE-SCALE FIRE TEST
Aircraft Ducting Materials / Narrow-Body Configuration

Ignition Source Outside

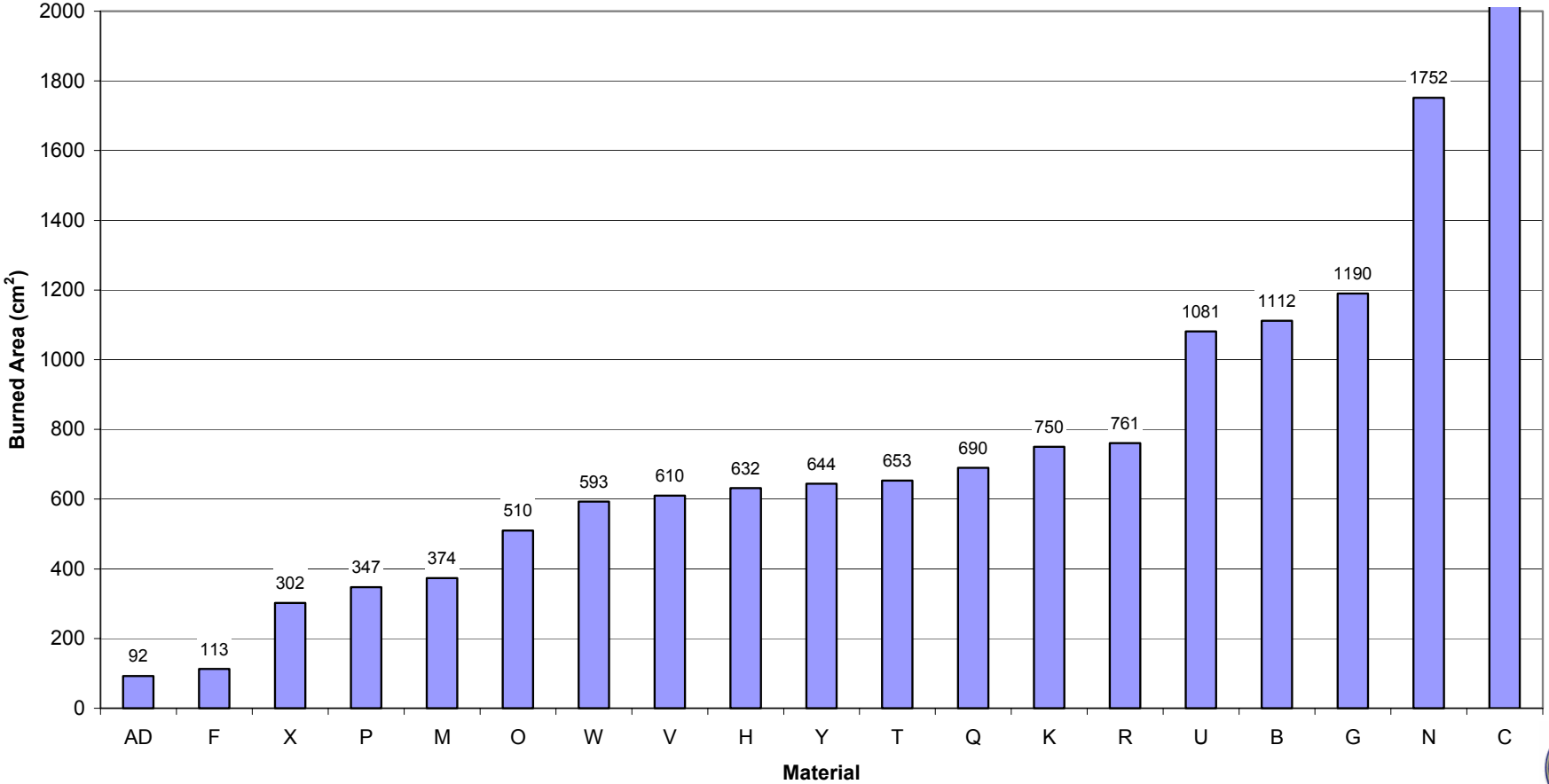


Results

32583

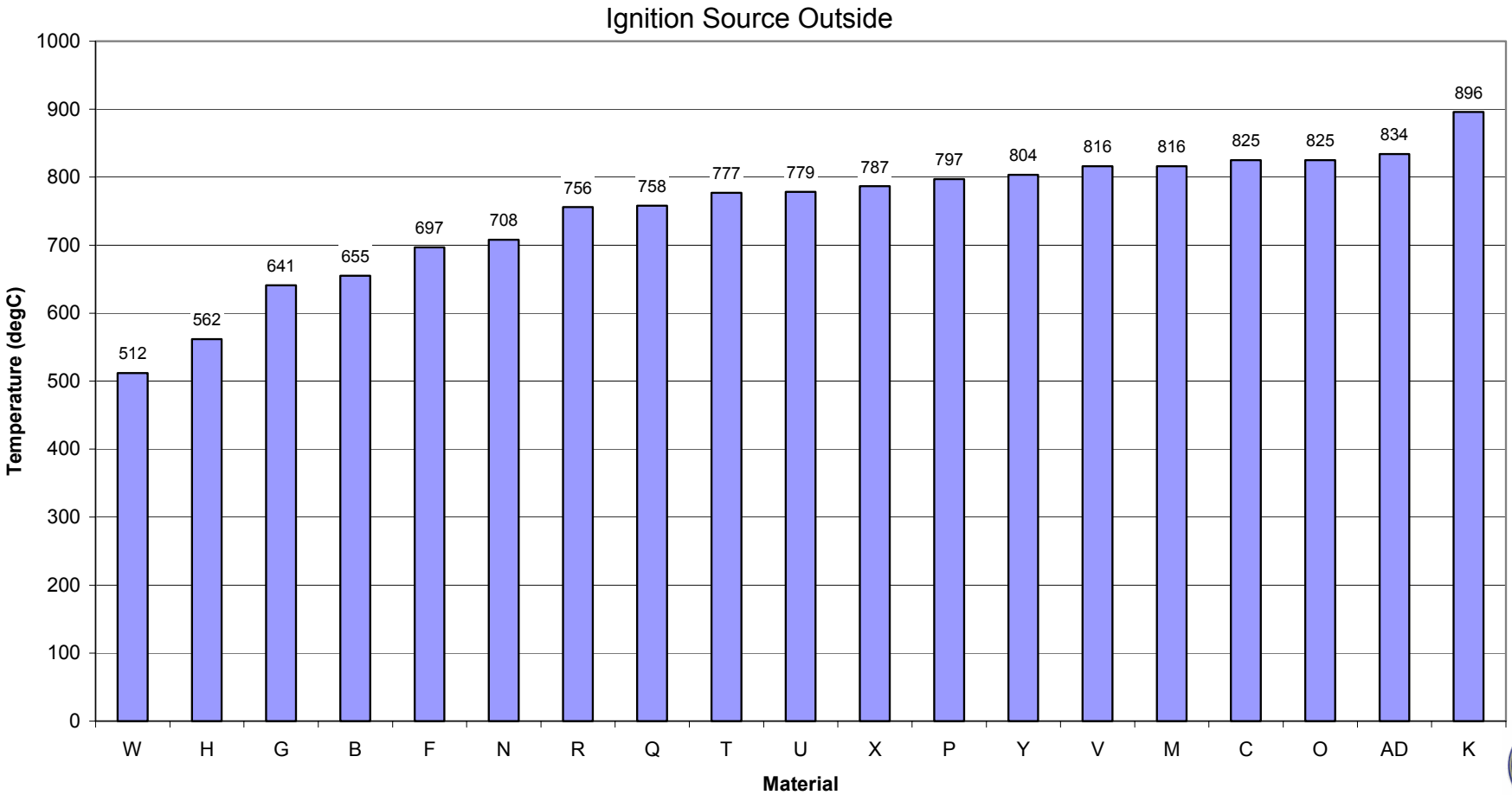
INTERMEDIATE-SCALE FIRE TEST
Aircraft Ducting Materials / Narrow-Body Configuration

Ignition Source Outside



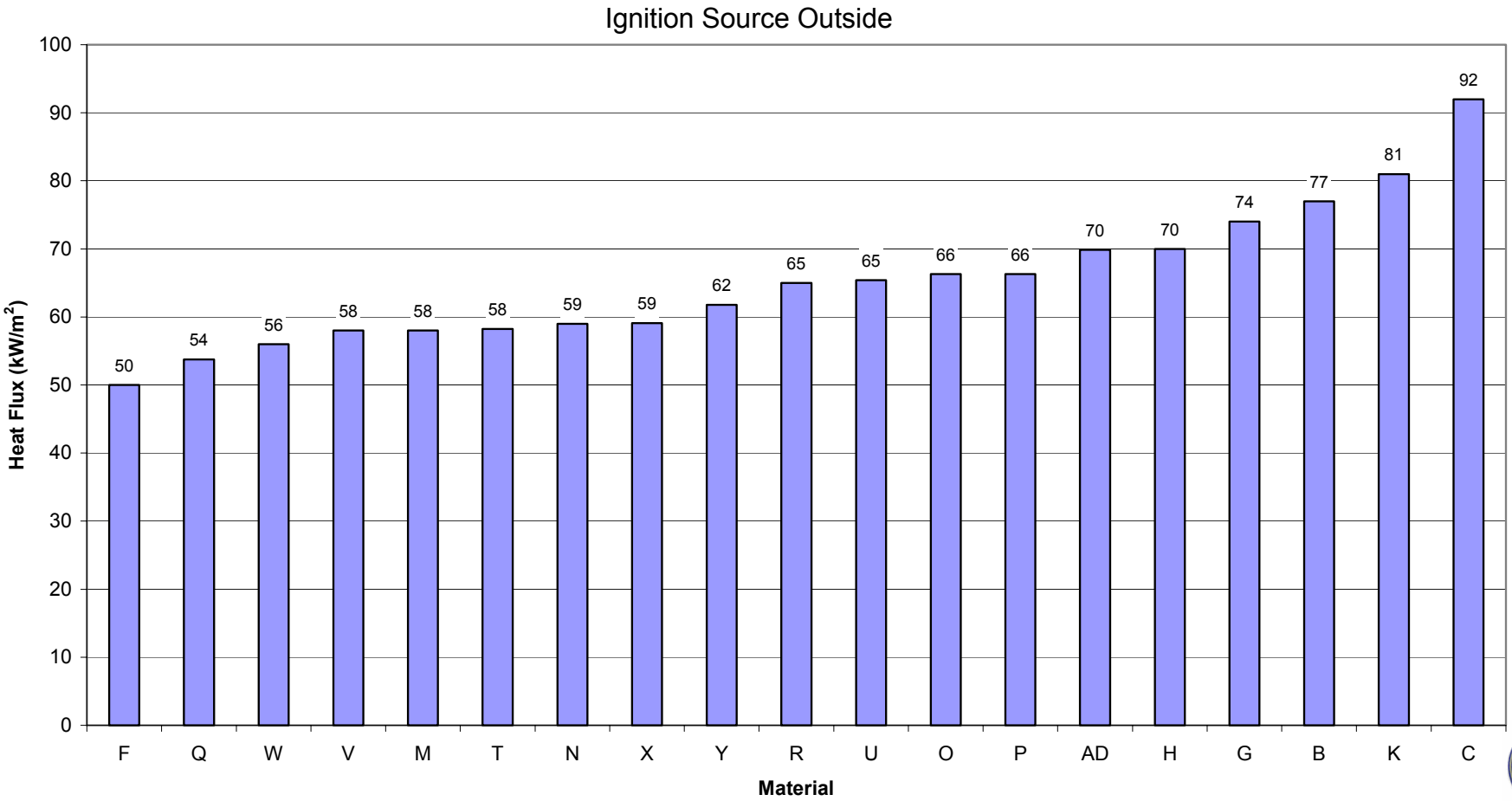
Results

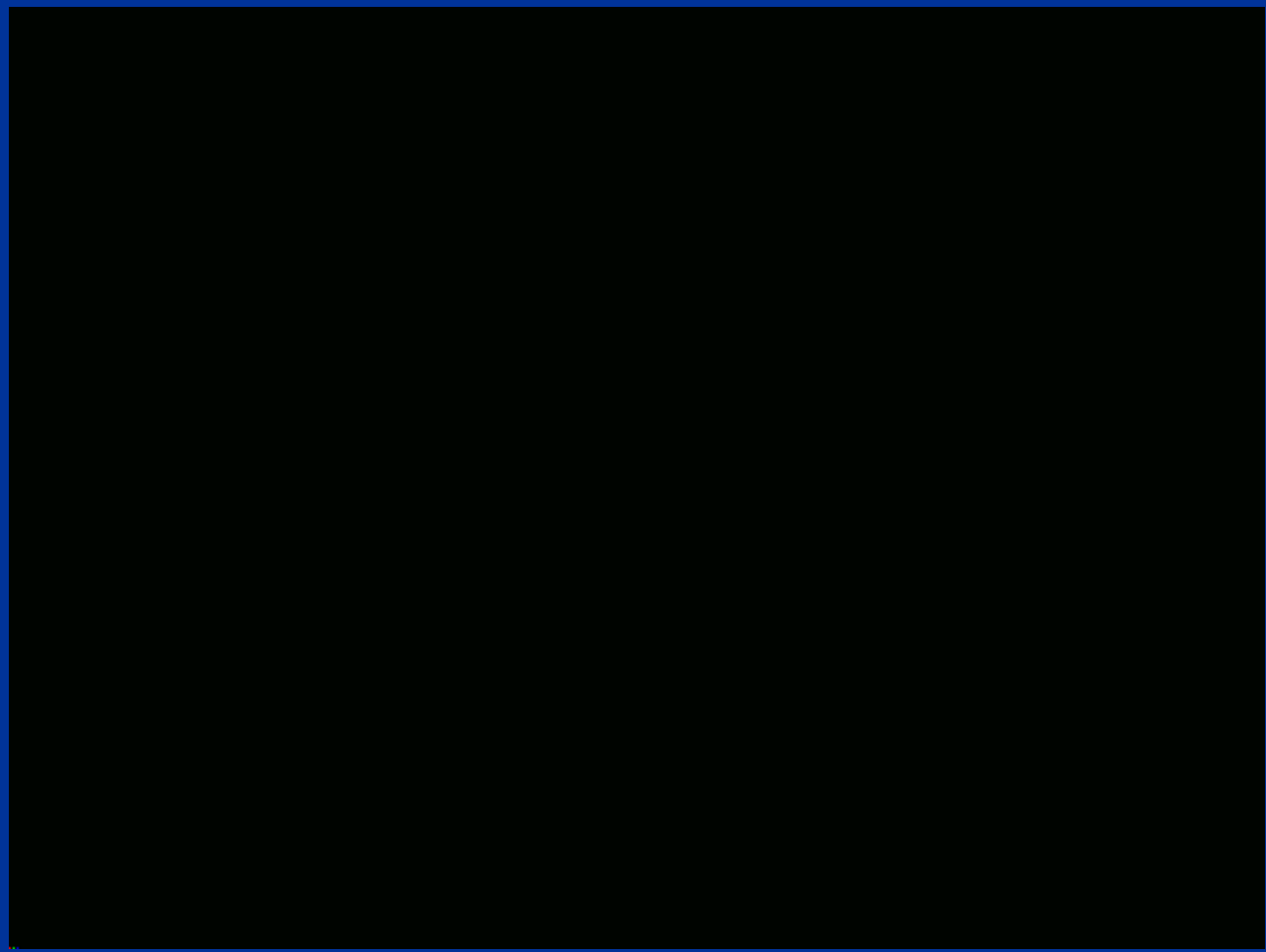
INTERMEDIATE-SCALE FIRE TEST
Aircraft Ducting Materials / Narrow-Body Configuration



Results

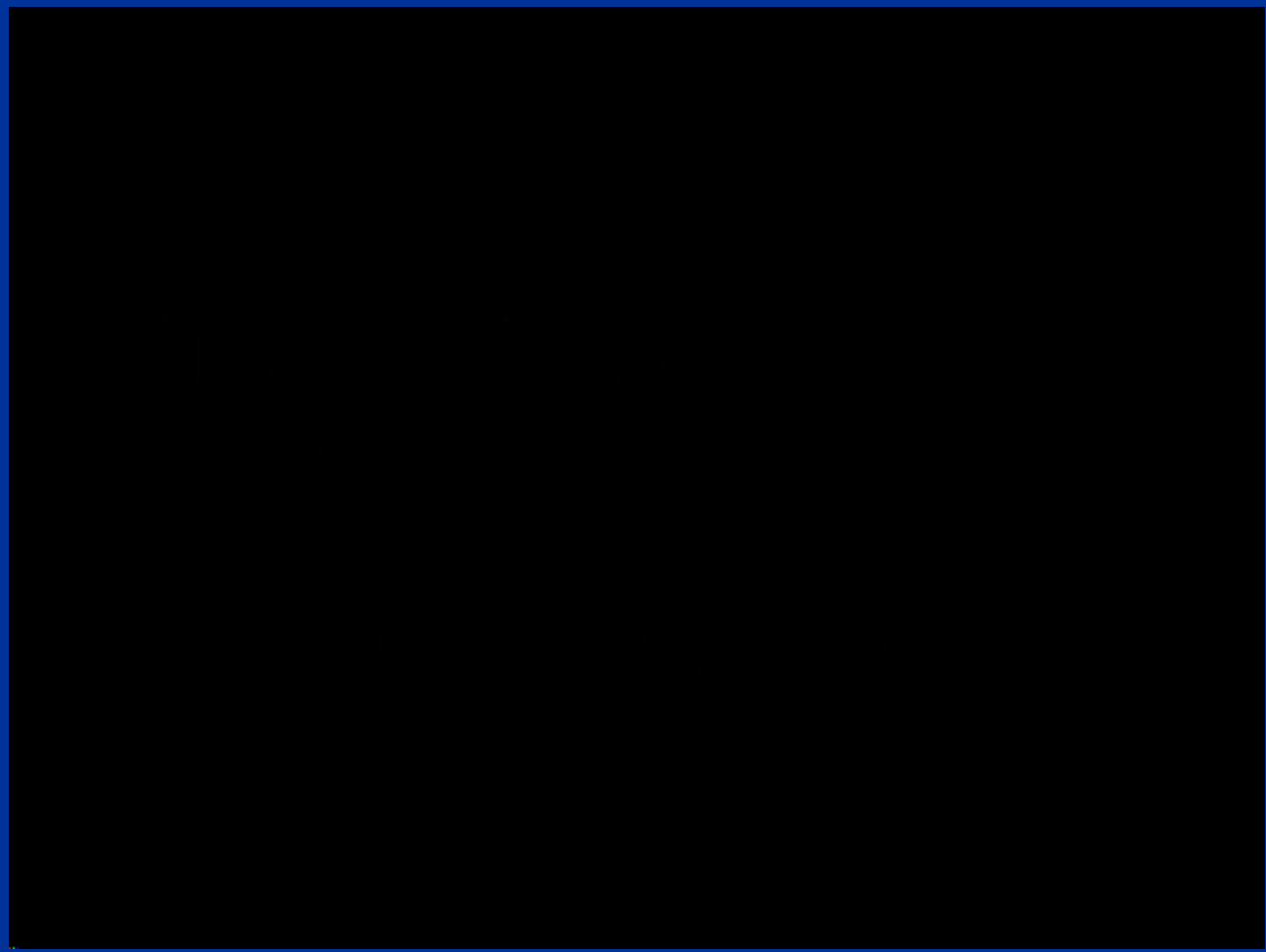
INTERMEDIATE-SCALE FIRE TEST
Aircraft Ducting Materials / Narrow-Body Configuration





Narrow-Body Configuration: Ignition Source Outside

Large Duct IST Test



Narrow-Body Configuration: Ignition Source Inside

Results

Narrow-Body Configuration: Ignition Inside

Narrow-Body Configuration: Ignition Inside

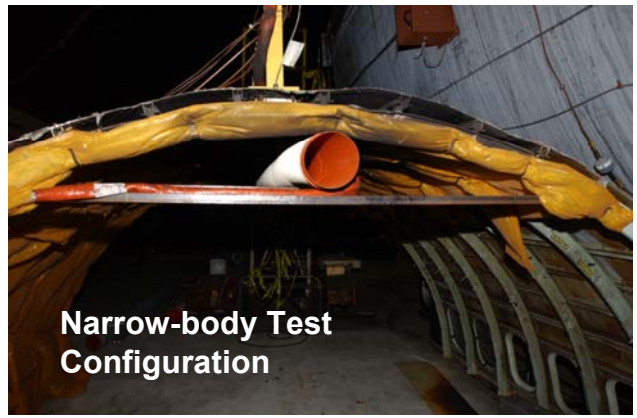
Wide-Body Configuration: Ignition Outside

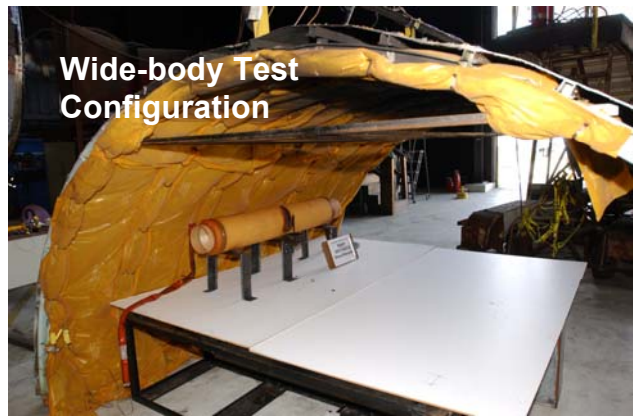
Wide-Body Configuration: Ignition In-Outside

Results

INTERMEDIATE-SCALE TEST (CONT.)

- The narrow-body test configuration was more severe than the wide-body test configuration (heat confined)
- The narrow-body configuration with the ignition source inside the duct was more severe that with the ignition source next to the duct outside (more heat from conduction, convection and radiation sources).


Narrow-body Test Configuration


Wide-body Test Configuration

Results

RADIANT PANEL TEST:

Test Protocol: Appendix F to Part 25 (Part IV) – Test Method To Determine the Flammability and Flame Propagation Characteristics of Thermal/Acoustic Insulation Materials

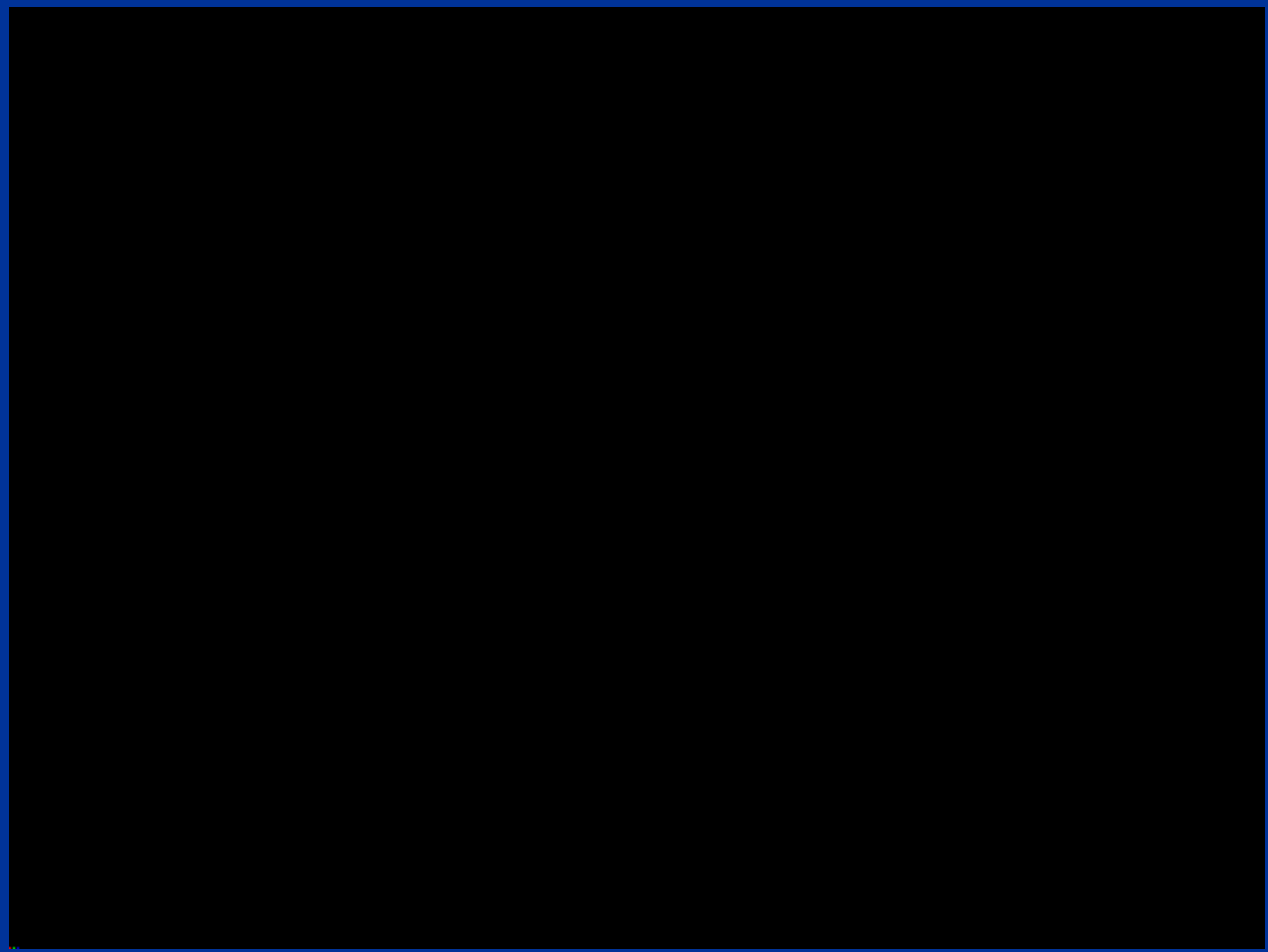
Sample Size: 318mm x 584mm

Heat Source: Propane Flame & Radiant Heating Coils (17 kW/m^2 panel, 147 kW/m^2 pilot)

Heat Source Exposure: 15 seconds (pilot) and until flames are extinguished (radiant panel)

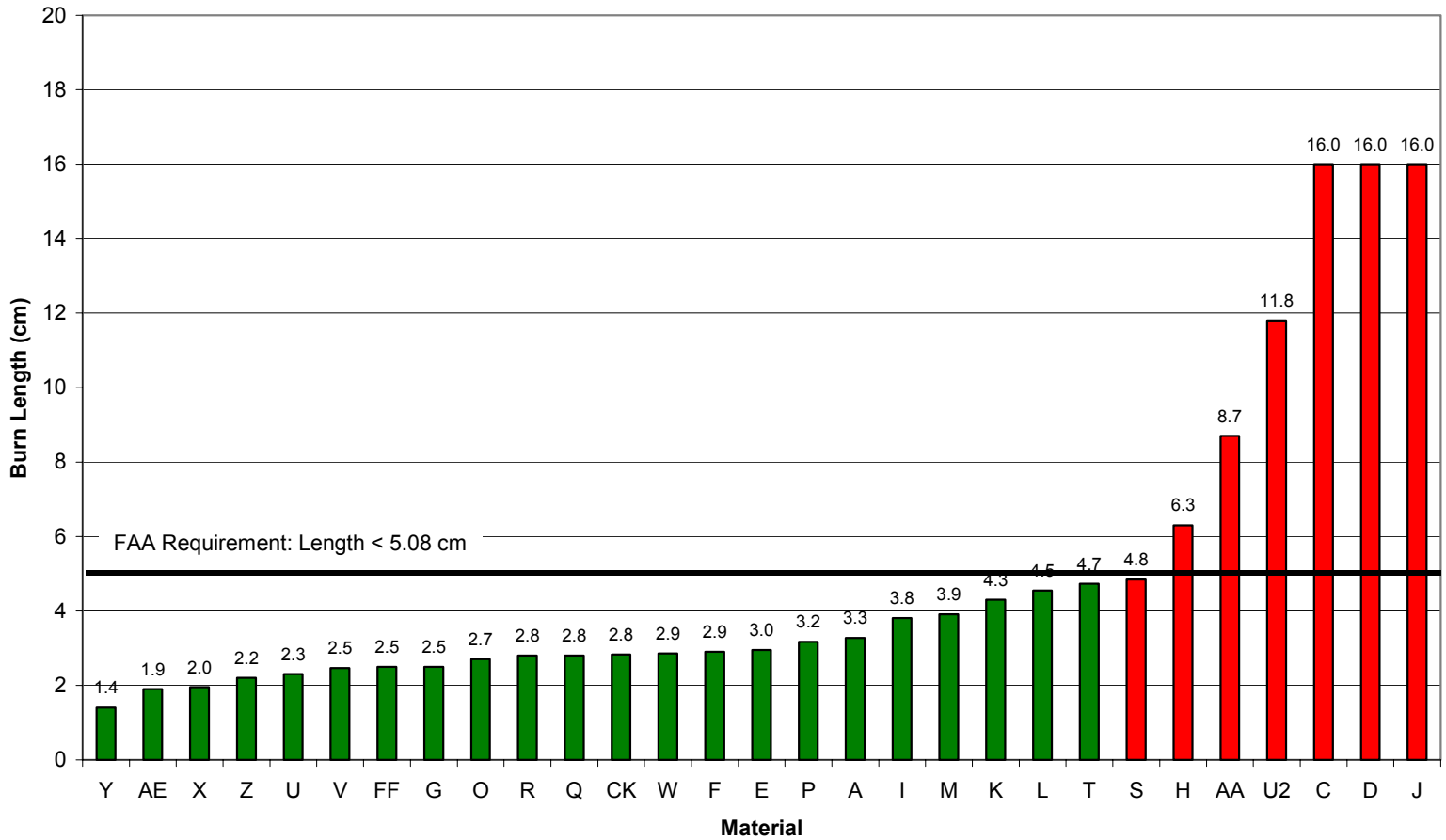
Max Flame Propagation: < 5.08 cm

Max Flame Time: < 3 seconds



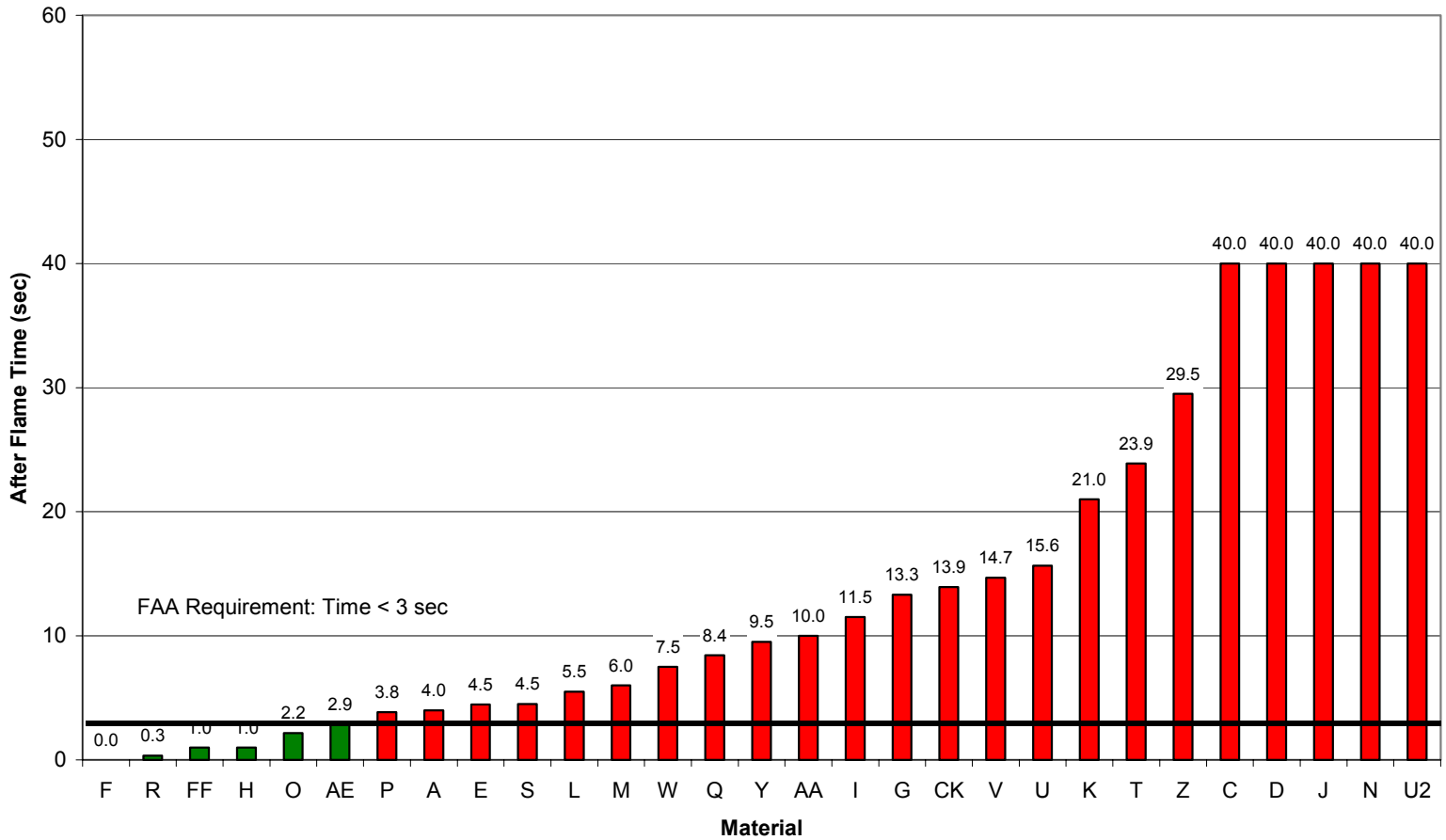
Results

RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials



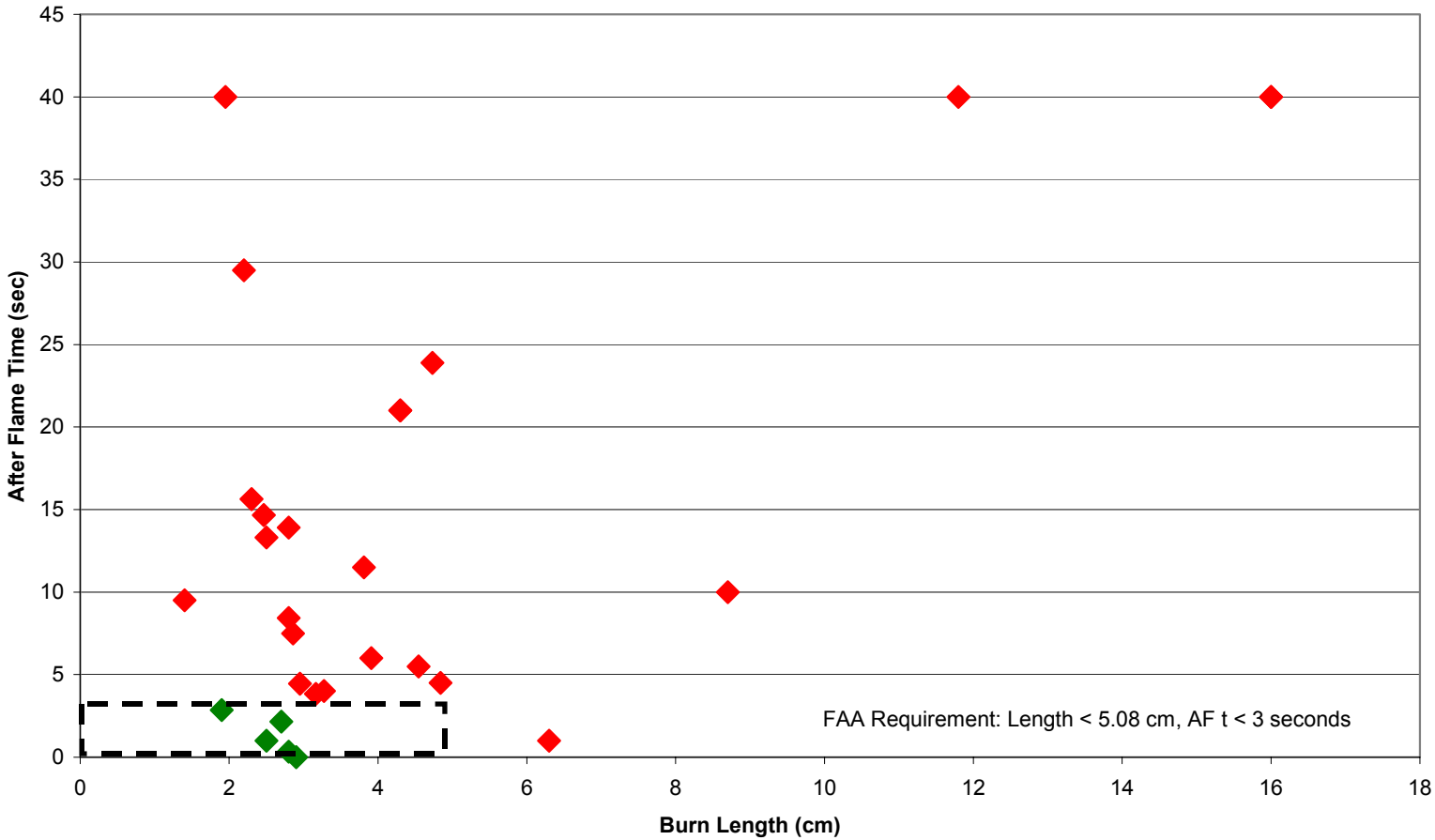
Results

RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials

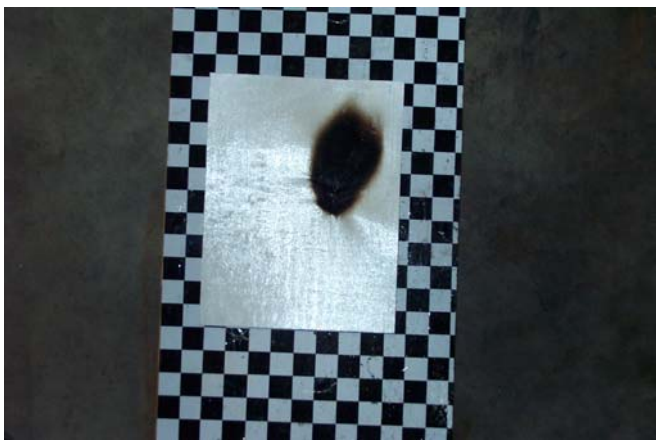


Results

RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials



Results



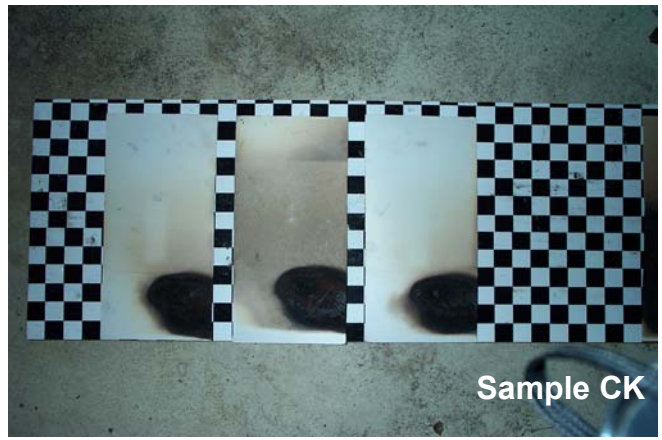
Passed Test - Sample O:
Burn Length = 2.7 cm
After Flame Time = 2.2 sec

Failed Test - Sample J:
Burn Length = +16 cm
After Flame Time = +40 sec

Results

FIRE PROTECTION COATING ON SAMPLE K

Failed Test, Sample K:
Burn Length = 4.3 cm
After Flame Time = 21 sec



Failed test, but improved Sample K:
Burn Length = 2.8 cm
After Flame Time = 13.9 sec

Results

RADIANT PANEL EXPERIMENTAL TEST:

Test Protocol: Same

Sample Size: Same

Heat Source: Same

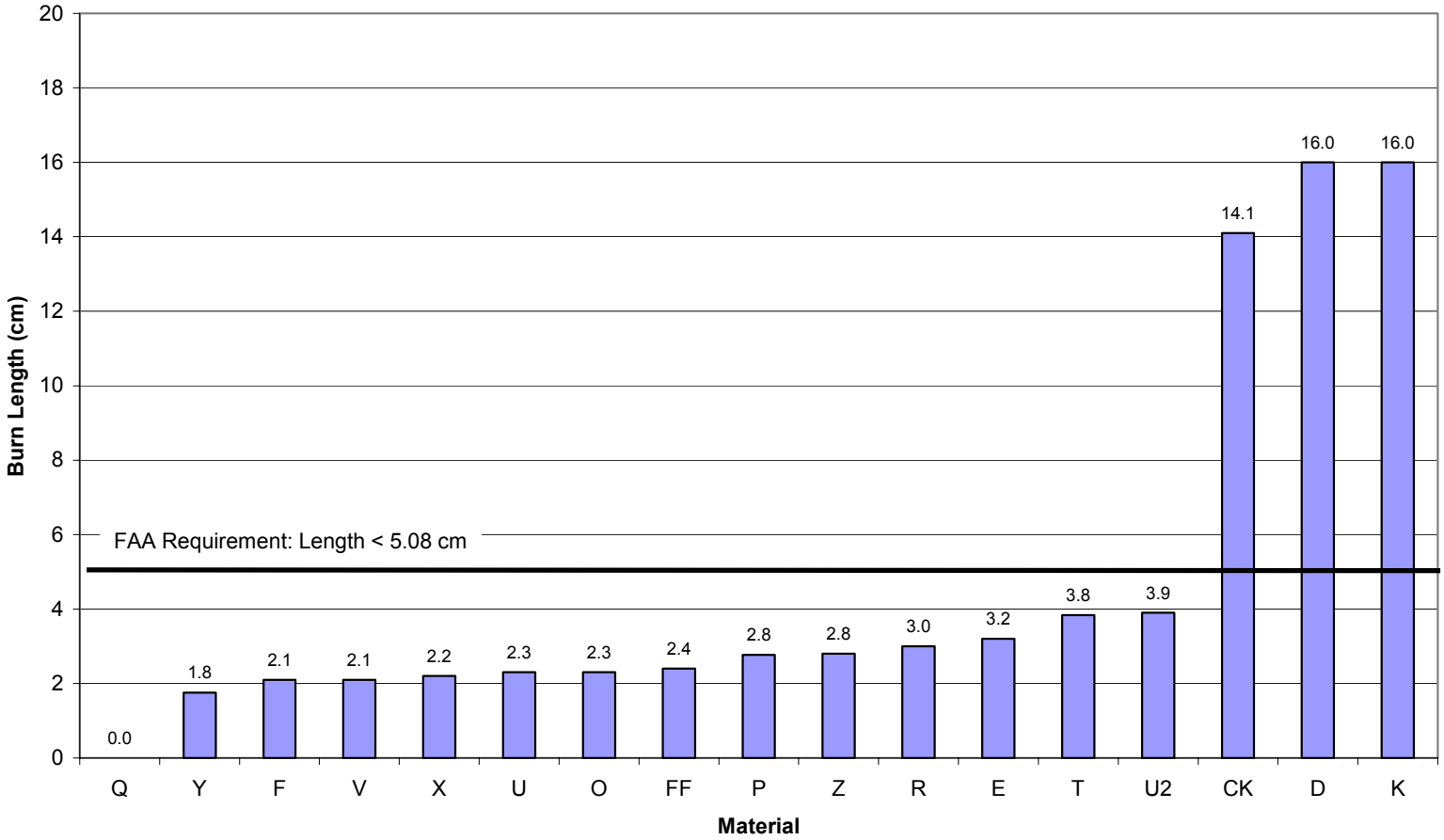
Heat Source Exposure: 1 minute exposed to radiant heat, 10 seconds pilot flame impingement

Max Flame Propagation: < 5.08 cm

Max Flame Time: < TBD

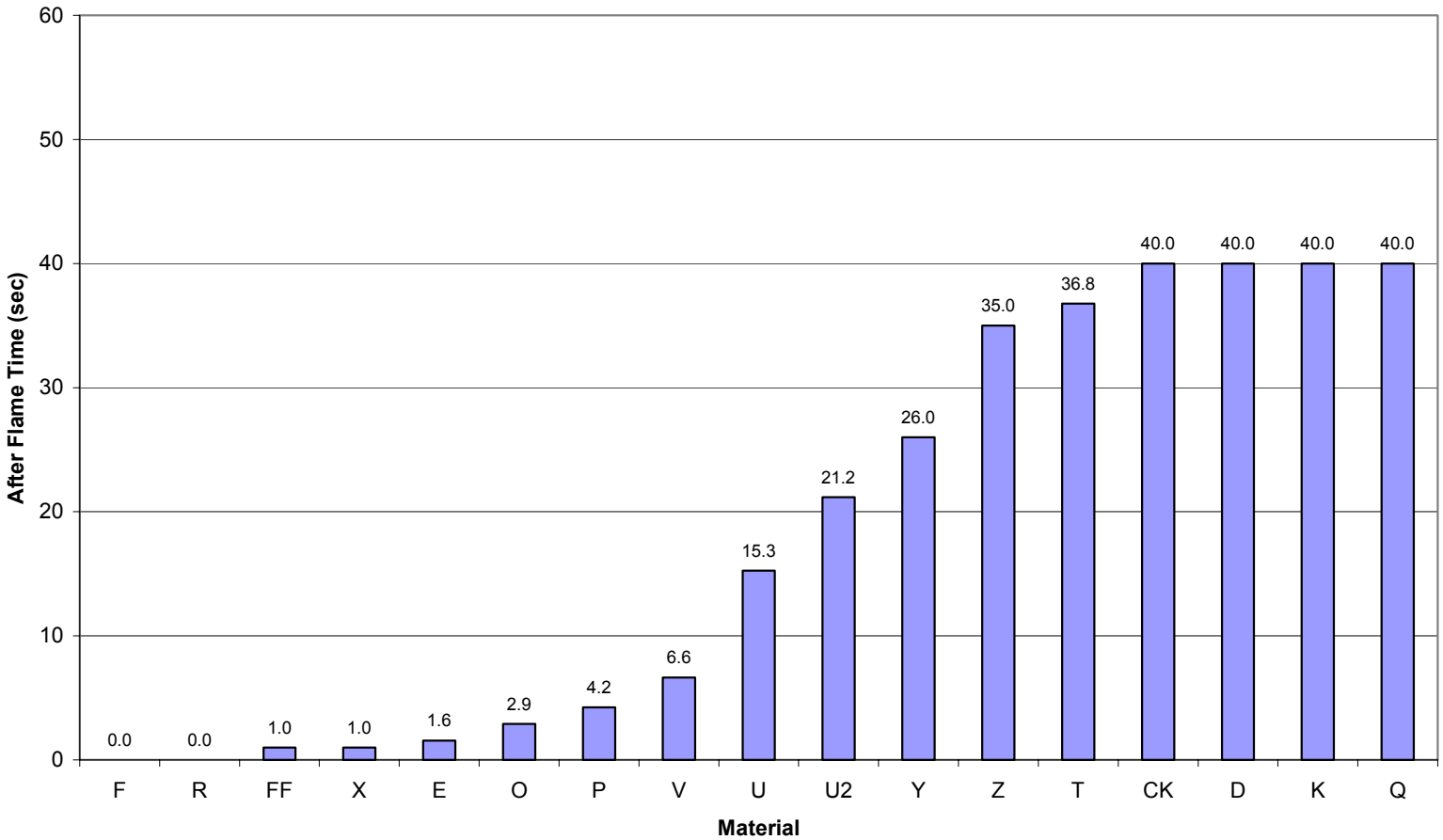
Results

EXPERIMENTAL RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials



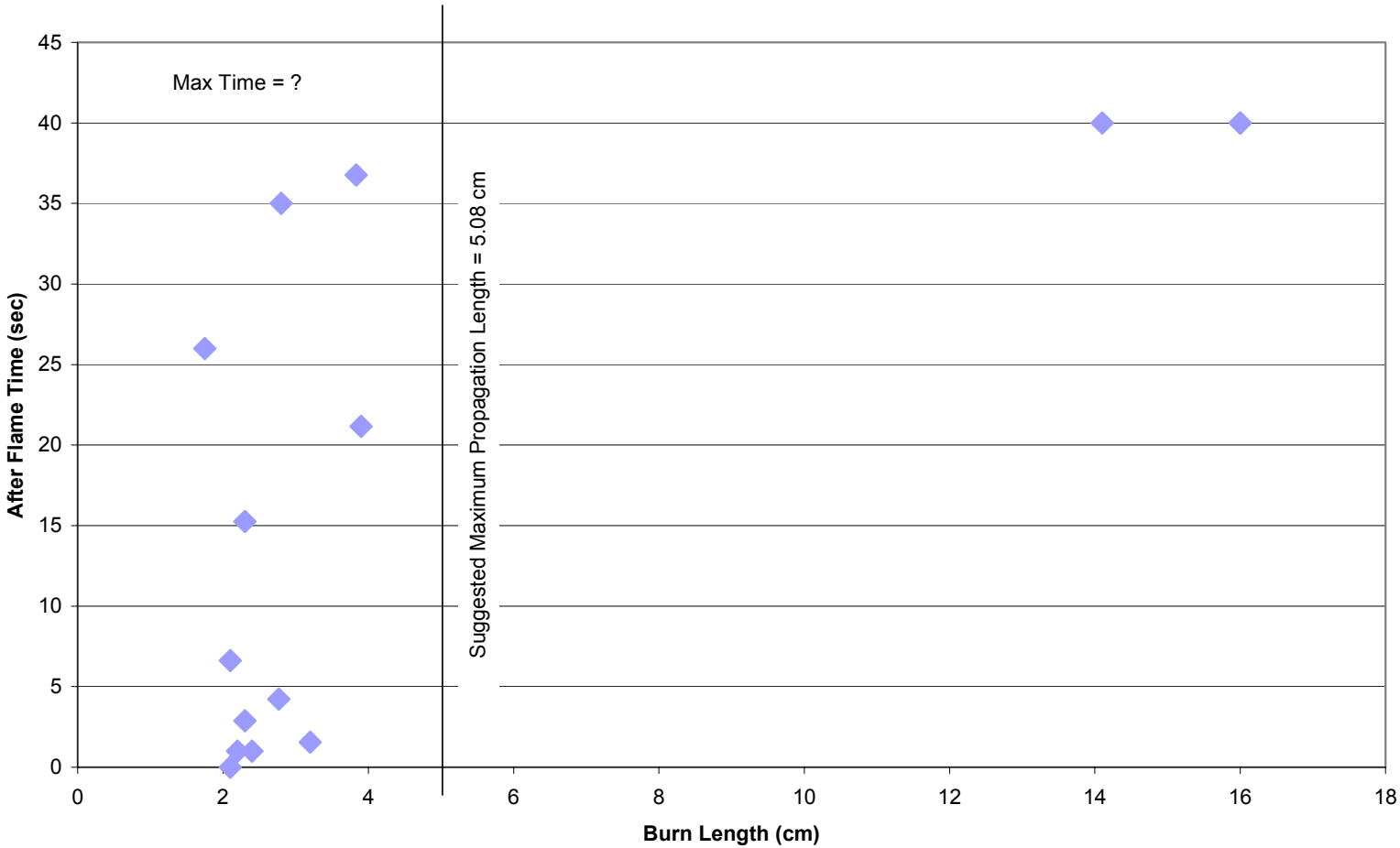
Results

RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials



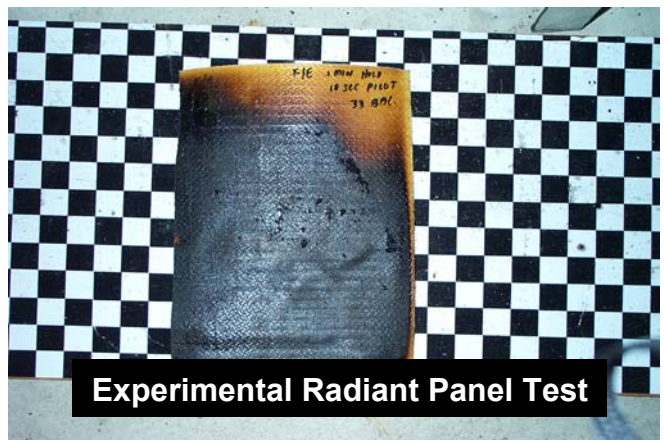
Results

EXPERIMENTAL RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials



Results

Sample O:
Burn Length = 2.3 cm
After Flame Time = 2.9 sec



Sample K:
Burn Length = +16 cm
After Flame Time = +40 sec

Results

HEAT RELEASE RATE TEST FOR CABIN MATERIALS:

Test Protocol: Chapter 5 of DOT/FAA/CT-89/15 Aircraft Material Fire Test Handbook

Sample Size: 150mm x 150mm

Heat Source: Methane Flame & Radiant Heating Coils (35 kW/m^2)

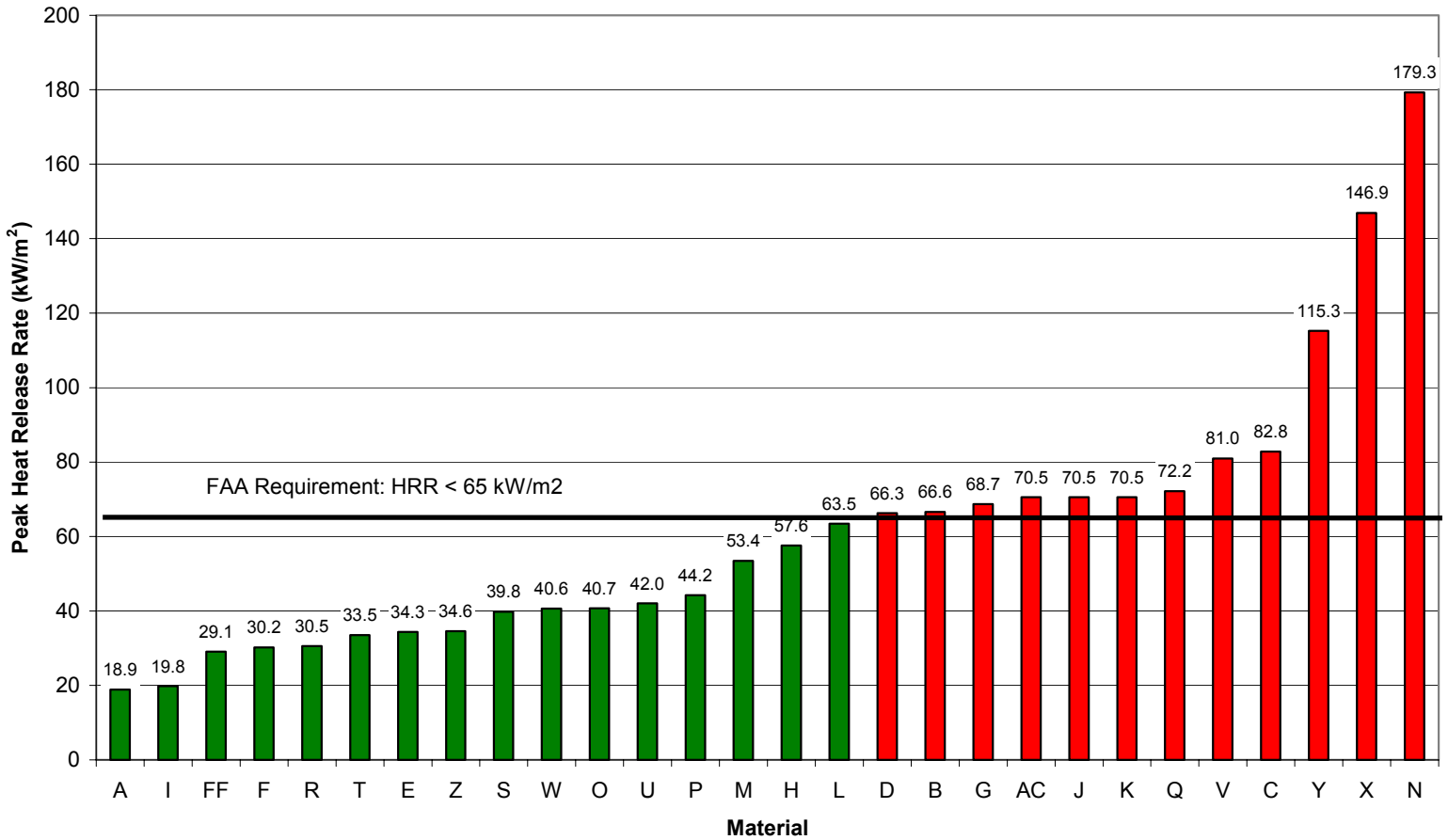
Heat Source Exposure: 5 minutes

Max Avg. Heat Release Rate: <65 kW/m^2

Max Avg. Total Heat Released (2 min): <65 kW*min/ m^2

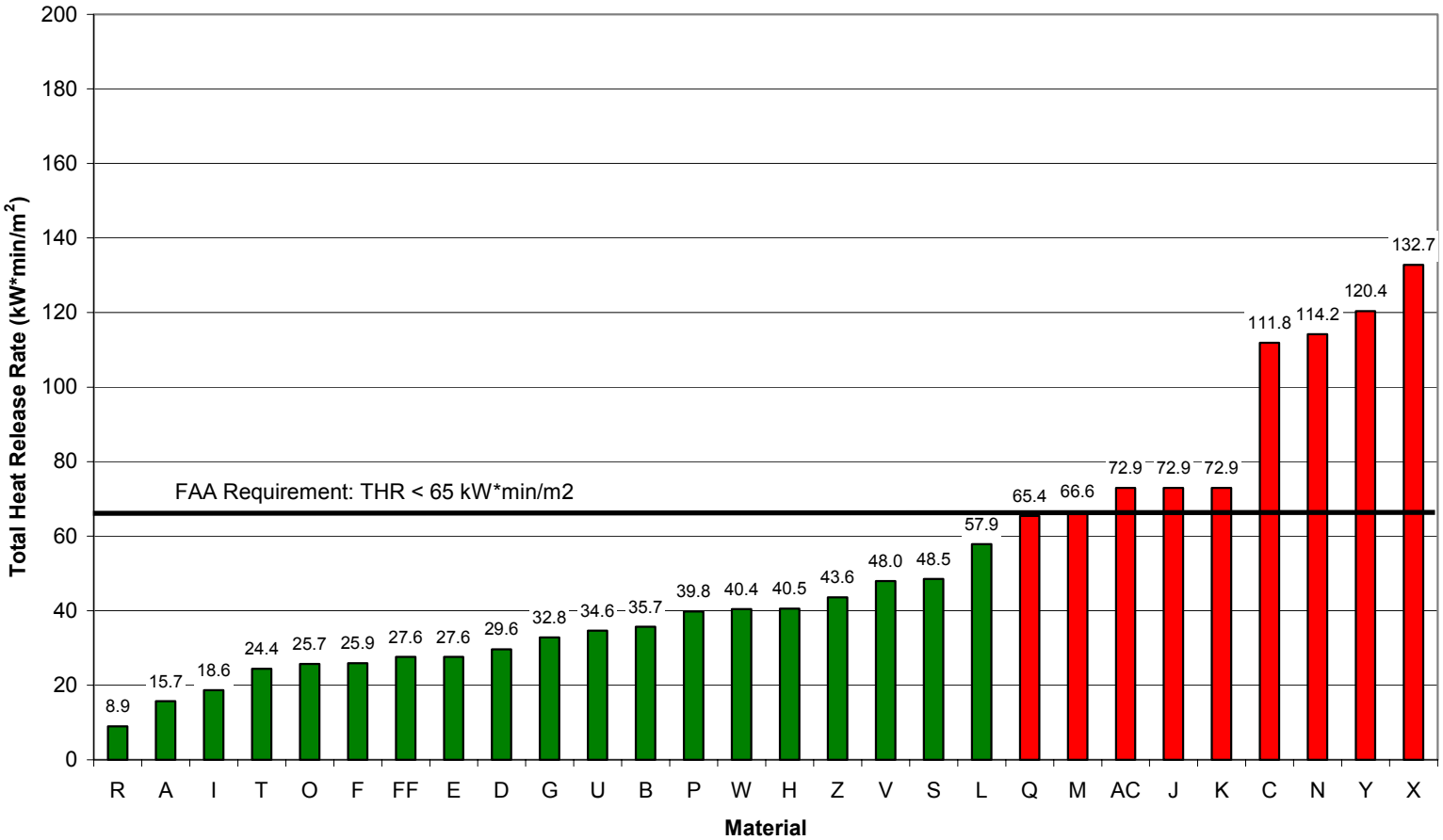
Results

FAA/OSU HEAT RELEASE TEST RESULTS
Aircraft Ducting Materials



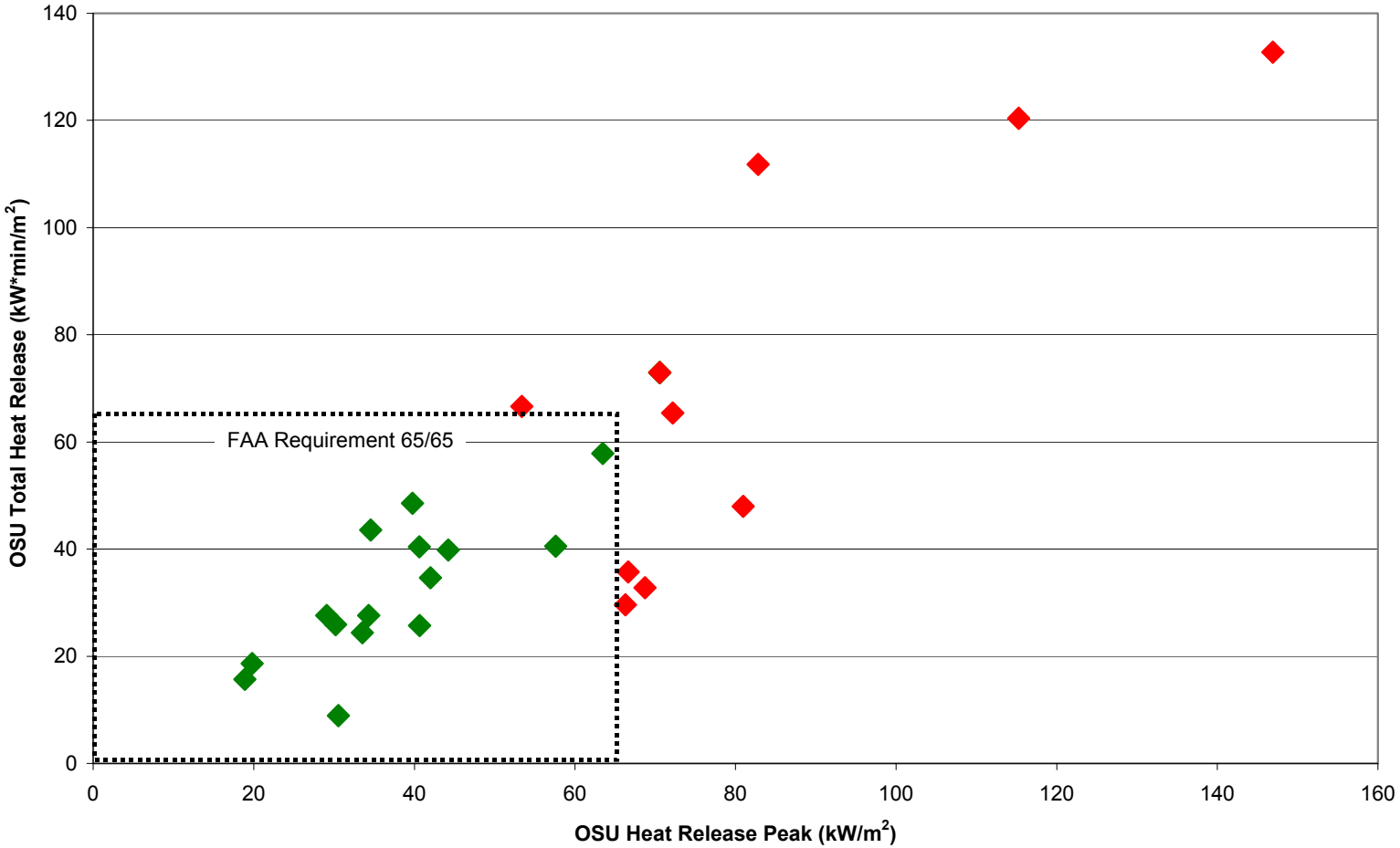
Results

FAA/OSU HEAT RELEASE TEST RESULTS
Aircraft Ducting Materials



Results

OSU HEAT RELEASE TEST
Aircraft Ducting Materials



Results

SMOKE TEST FOR CABIN MATERIALS:

Test Protocol: Chapter 6 of DOT/FAA/CT-89/15 Aircraft Material Fire Test Handbook

Sample Size: 73mm x 73mm

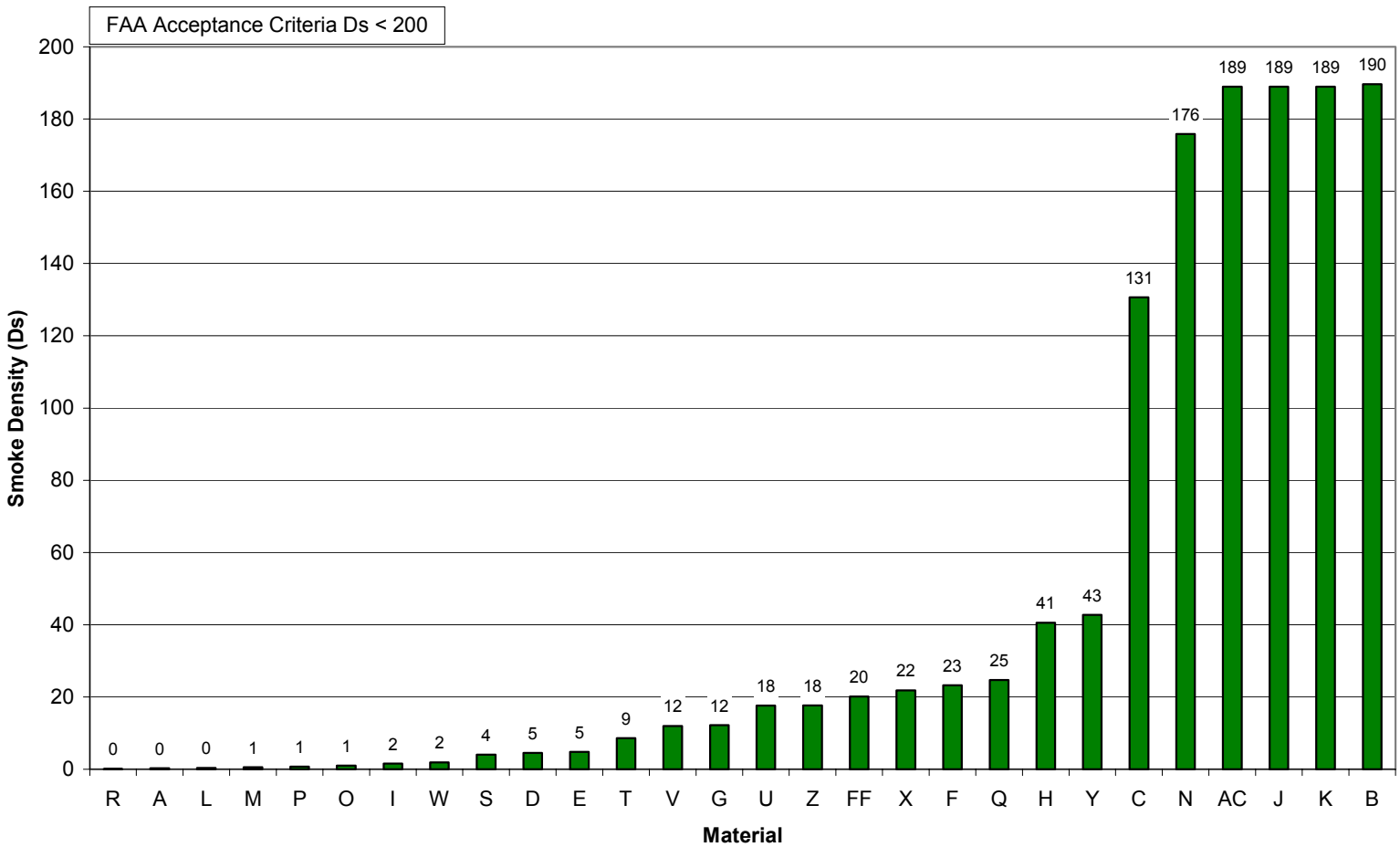
Heat Source: Methane Flame & Radiant Heating Coils (25 kW/m^2)

Heat Source Exposure: 4 minutes

Max Avg. Specific Optical Density, Dm: <200

Results

FAA/NBS SMOKE TEST RESULTS
Aircraft Ducting Materials



Results

MICRO-SCALE COMBUSTION CALORIMETER TEST:

Test Protocol: FAA Report DOT/FAA/AR-01/117 A Micro-scale Combustion Calorimeter

Sample Size: milligram range

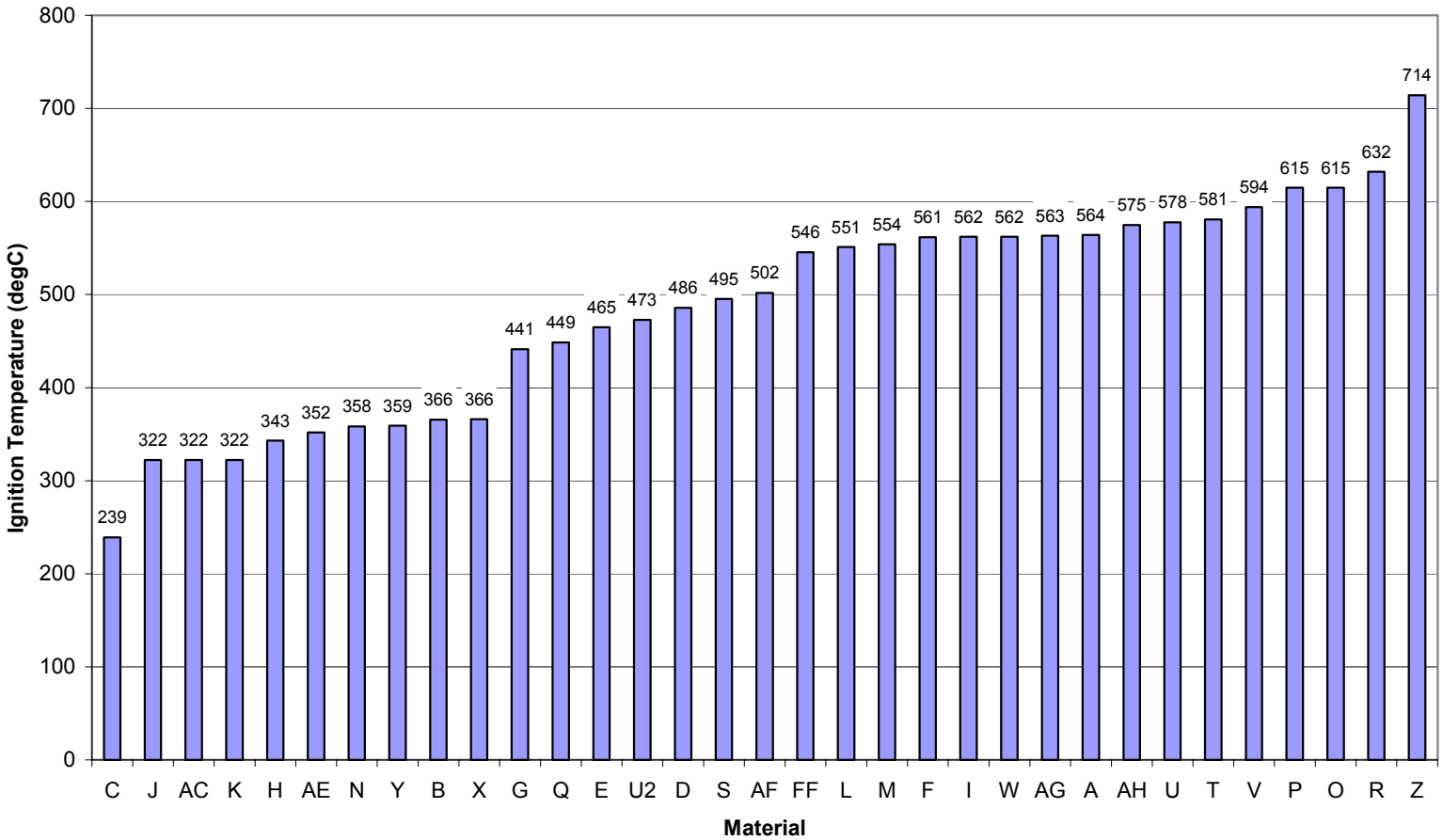
Heat Source: Heating Coils (900 ºC)

Heat Source Exposure: 10 to 120 seconds to effect pyrolysis

Not a compliance test

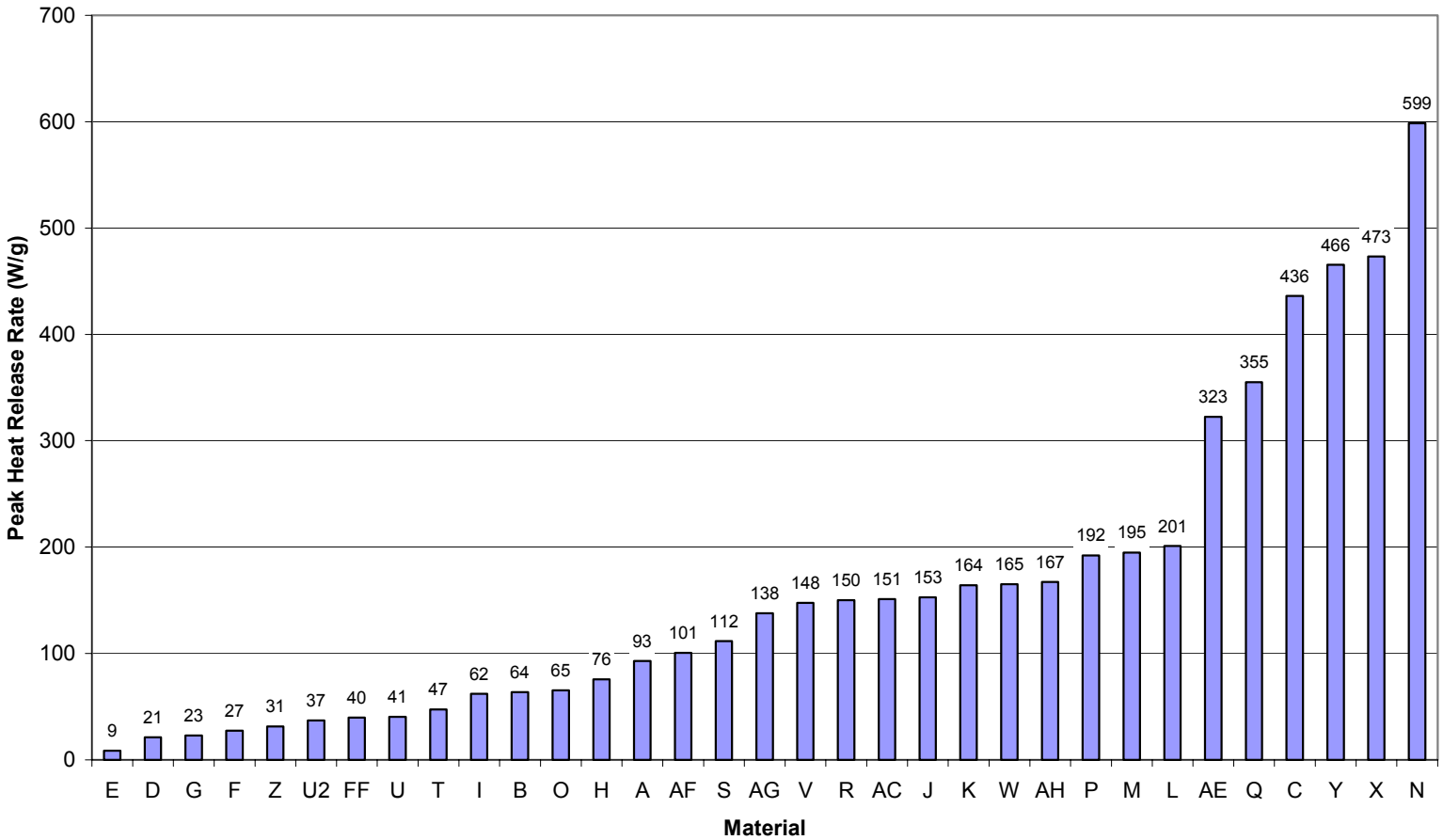
Results

MICRO-SCALE COMBUSTION CALORIMETER TEST RESULTS
Aircraft Ducting Materials



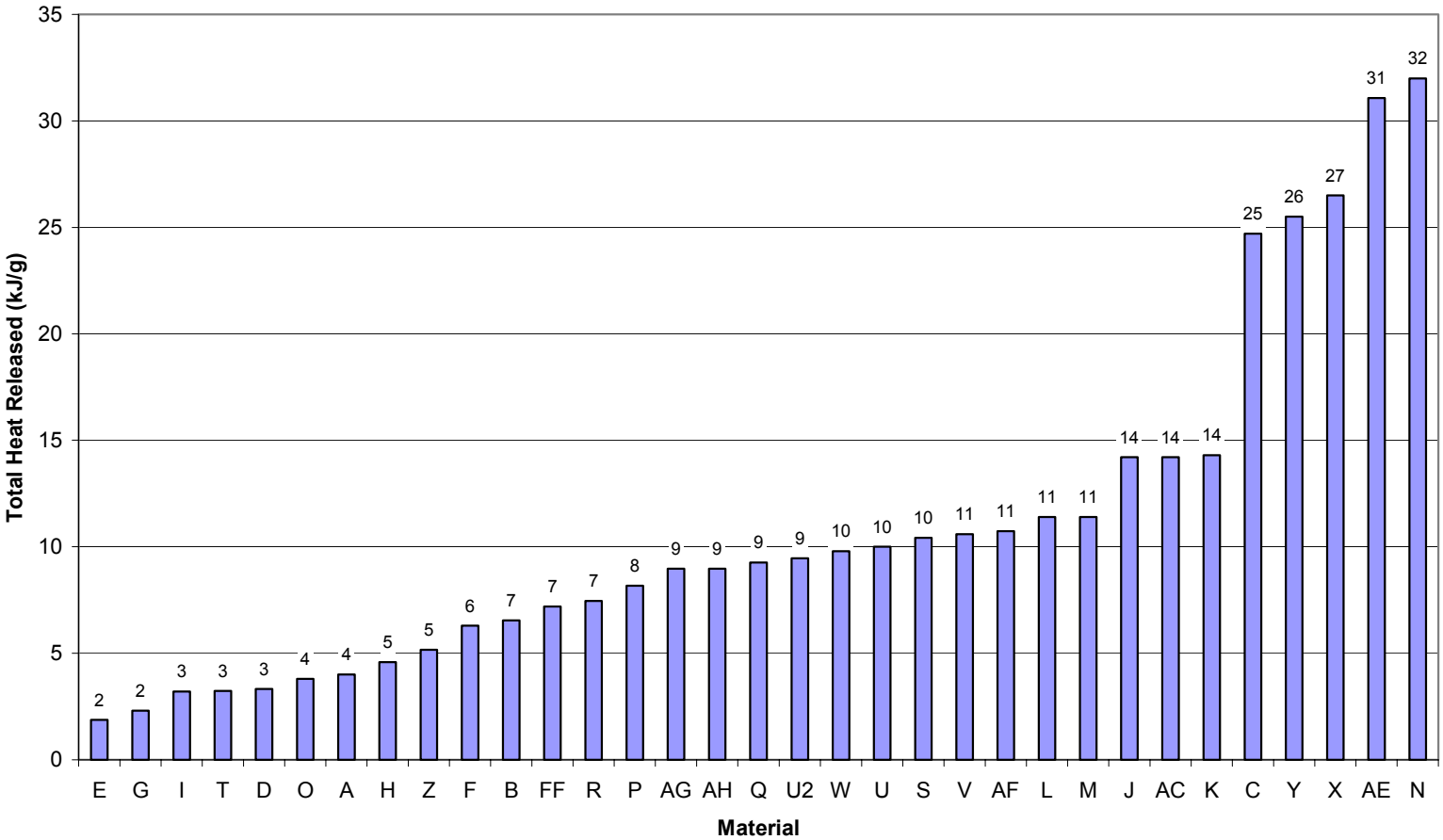
Results

MICRO-SCALE COMBUSTION CALORIMETER TEST RESULTS
Aircraft Ducting Materials



Results

MICRO-SCALE COMBUSTION CALORIMETER TEST RESULTS
Aircraft Ducting Materials



Results

Therefore, a good fire worthy material is one that has a:

- High Ignition Temperature (at least higher than the expected fire threat)
- Low Total Heat Release
- Low Heat Release Rate
- Low Smoke Emission
- Low Propagation Capacity

Results

Material Fireworthiness Ranking:

Best

Worst

12 VBB Material	Final Rank
R	1
U	2
X	3
Y	3
H	4
P	4
O	5
N	6
T	6
K	7
Q	8
B/AB	9
F	10
G	11
M	12
W	13
C	14
V	15

MATERIAL	FINAL RANK
R	1
O	2
P	3
W	4
F	5
T	6
M	7
U	8
G	9
V	10
H	11
Q	12
Y	13
X	14
B	15
C	16
K	17
N	18

* Ranking based on FAA's OSU heat release, NBS smoke, and Radiant Panel propagation tests.

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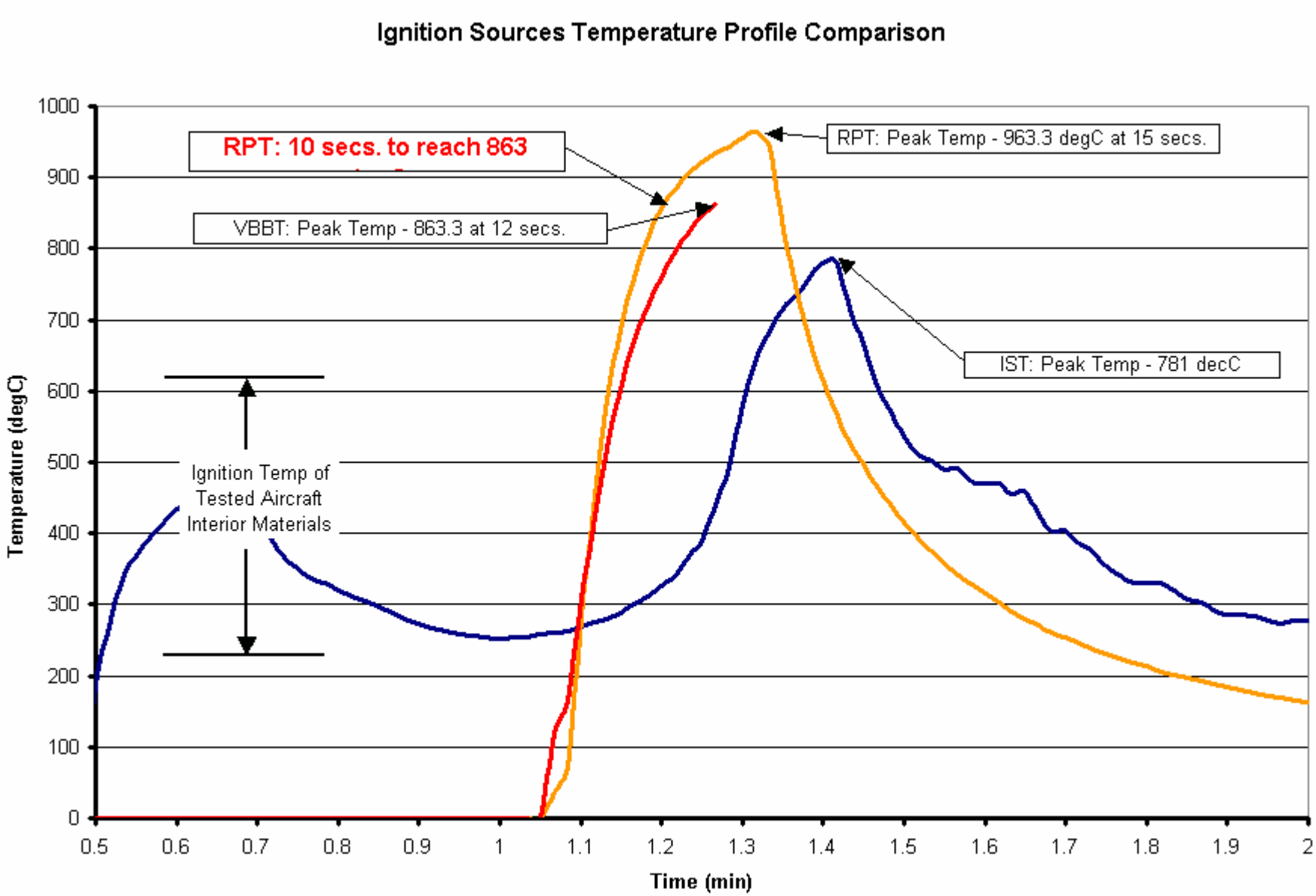
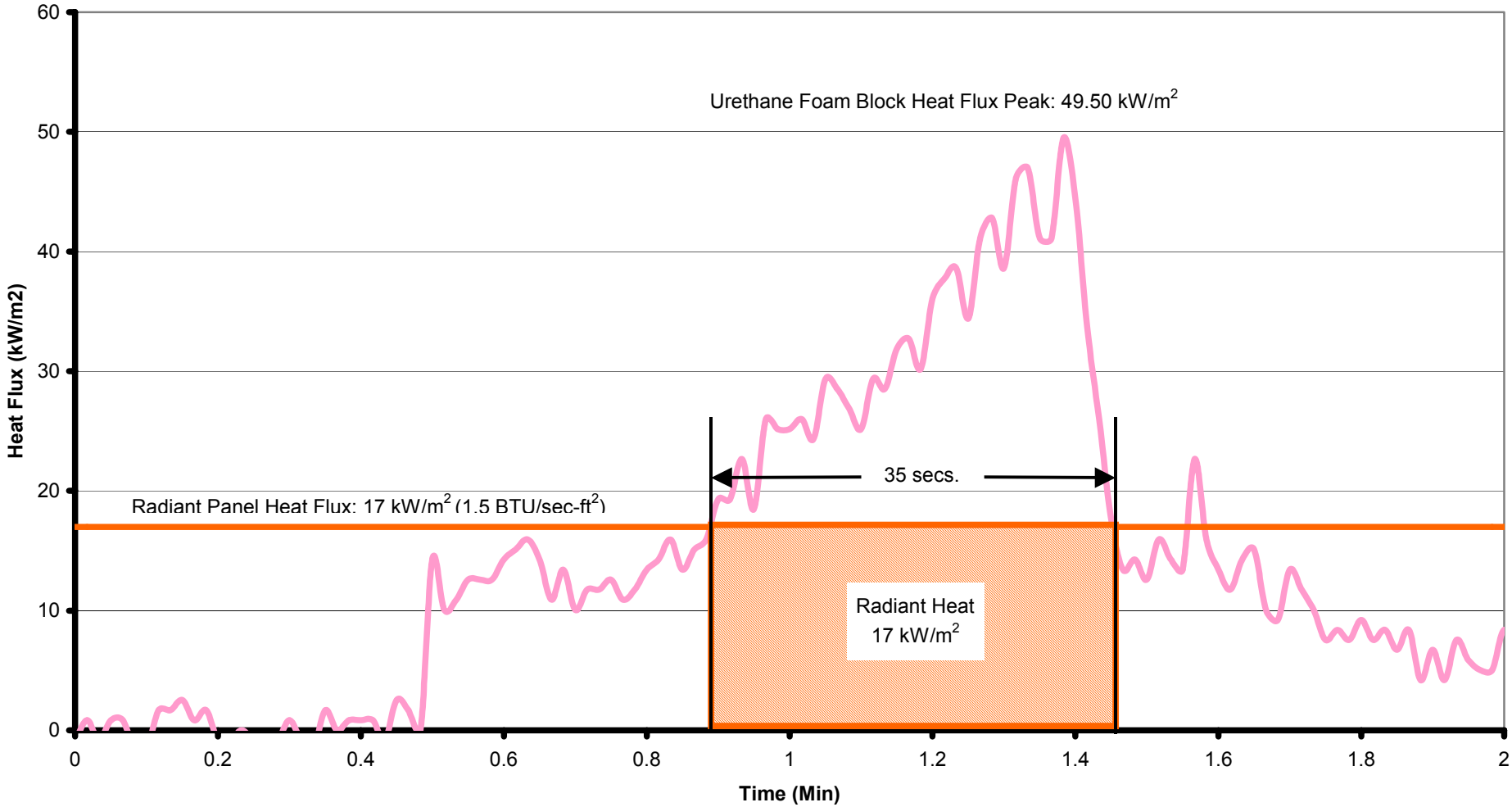
Discussion

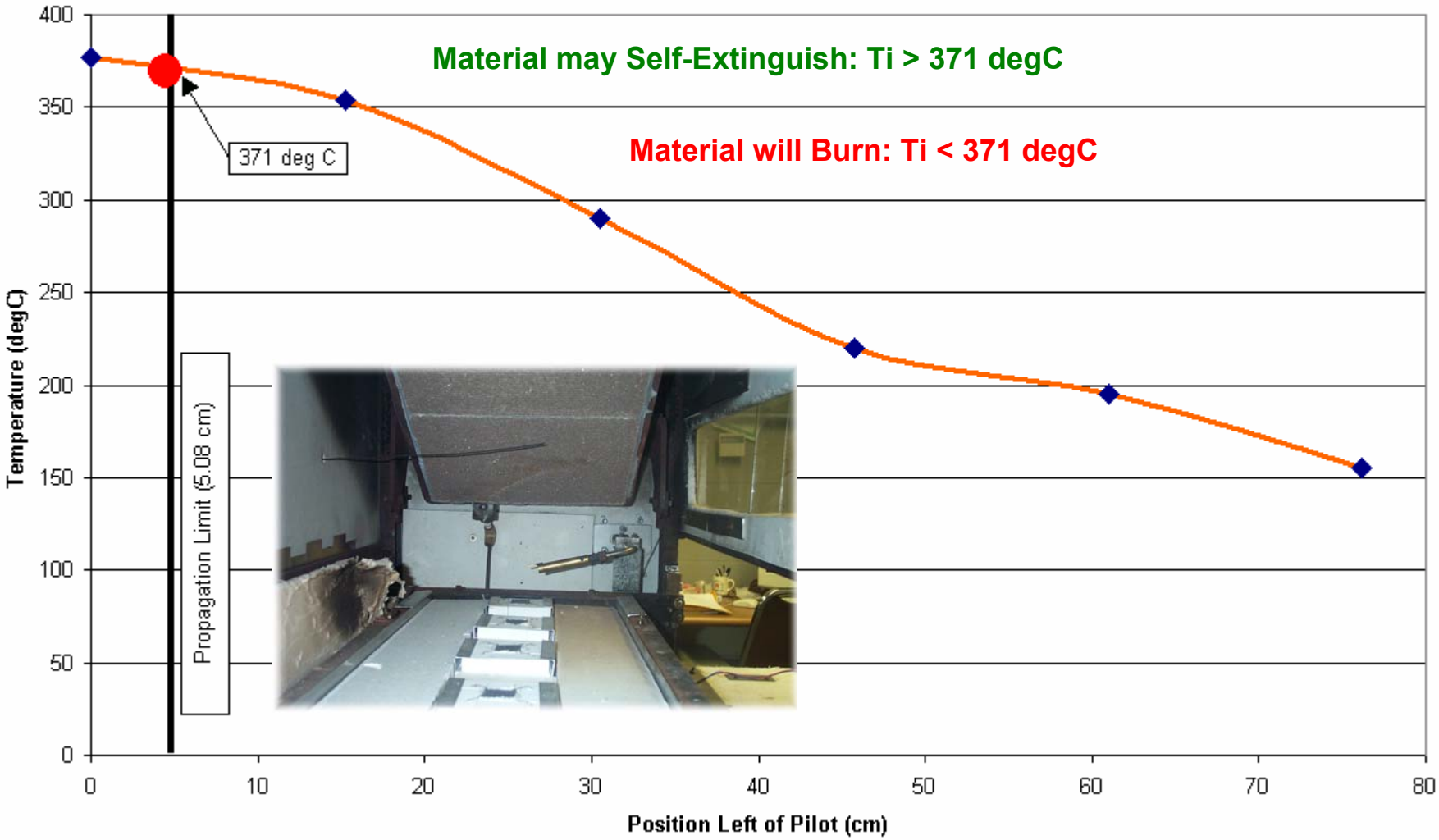
INTERMEDIATE-SCALE TEST VS RADIANT PANEL TEST


Ignition Sources Temperature Profile Comparison
RPT: 10 secs. to reach 863
RPT: Peak Temp - 963.3 degC at 15 secs.
VBBT: Peak Temp - 863.3 at 12 secs.
IST: Peak Temp - 781 decC
Ignition Temp of Tested Aircraft Interior Materials
Temperature (degC)
Time (min)
0
100
200
300
400
500
600
700
800
900
1000
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2

Urethane Foam Block (Igniter) Heat Flux Profile During Intermediate-Scale Test



Radiant Panel Temperature Profile on Tray
(Gas System with Pilot Off)



Discussion

RANKING COMPARISON

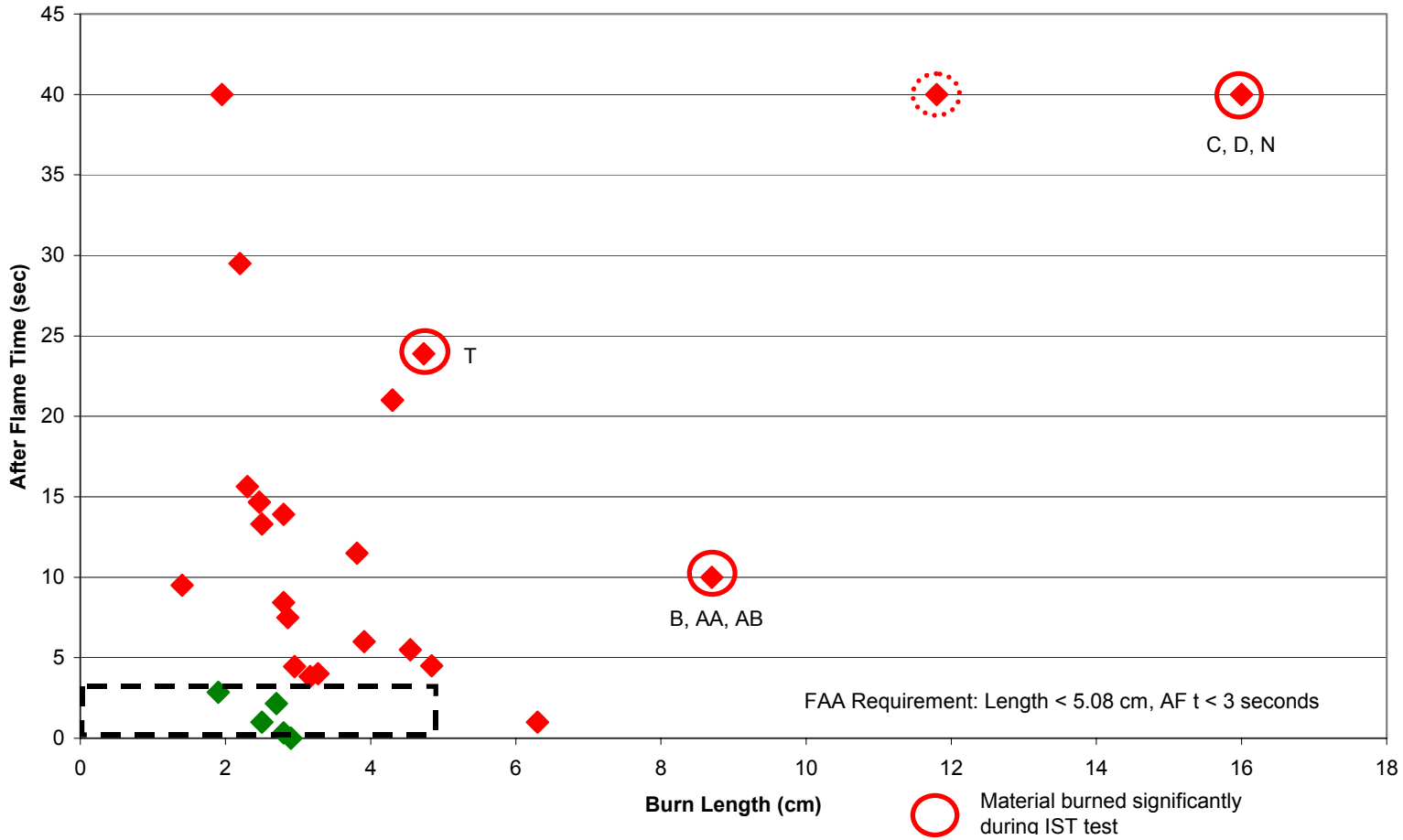
IST Material	Final Rank
F	1
W	2
Q	3
X	3
M	4
H	5
T	5
V	5
P	6
N	7
R	7
Y	8
AD*	9
O	10
G	11
U	11
B/AB	12
K	13
C	14

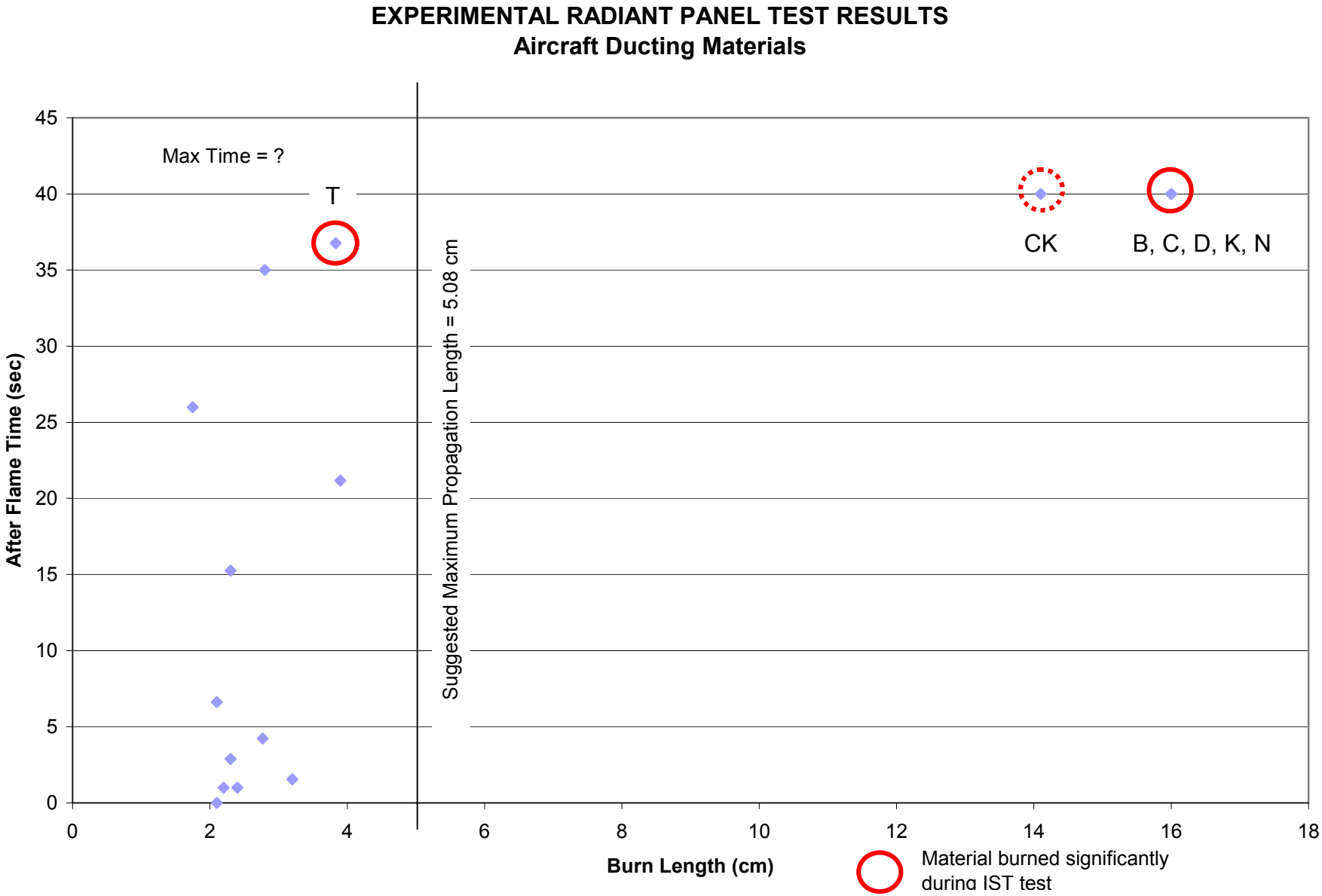
RP	FINAL RANK
F	1
R	1
O	2
P	2
Y	2
Q	3
W	3
G	4
H	4
M	4
U	4
V	4
X	5
B/AA/AB	6
K	7
T	7
C	8
N	8

EX RP	FINAL RANK
F	1
O	2
R	2
V	2
X	2
Y	3
P	4
Q	4
U	5
T	6
C	7
K	7
N	7

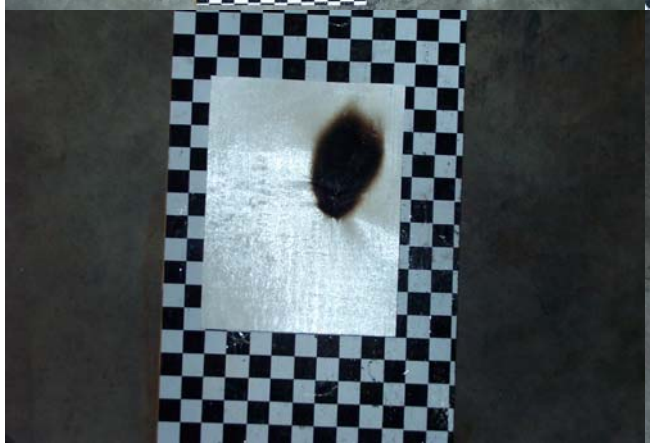
Discussion

RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials




EXPERIMENTAL RADIANT PANEL TEST RESULTS
Aircraft Ducting Materials
After Flame Time (sec)
45
40
35
30
25
20
15
10
5
0
Max Time = ?
T
Suggested Maximum Propagation Length = 5.08 cm
CK
B, C, D, K, N
0
2
4
6
8
10
12
14
16
18
Burn Length (cm)
Material burned significantly during IST test

Discussion

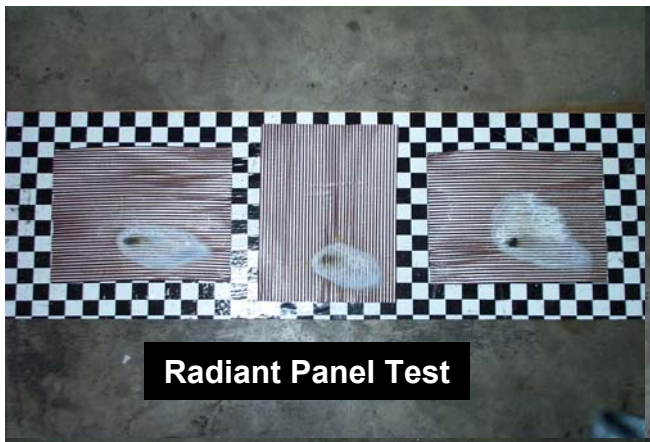
	Radiant Panel Test	Intermediate-Scale Test (Fire Outside)
Sample D →		
Sample O →		

Discussion

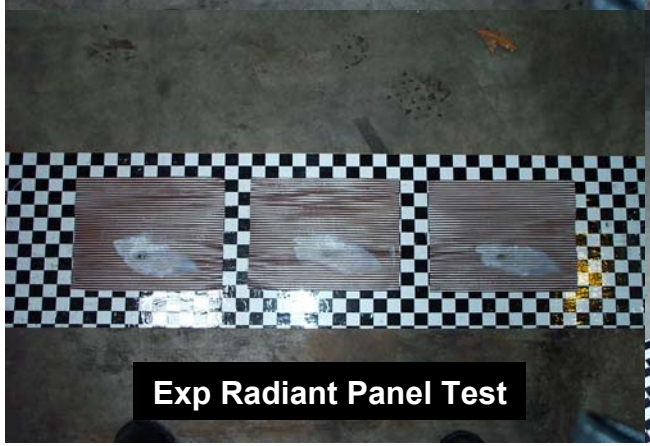
	Exp Radiant Panel Test	Intermediate-Scale Test (Fire Inside)
Sample D → (Failed)		
Sample O → (Passed)		

Discussion

Sample T → (Failed)



Sample T → (Failed)



Discussion

What's Next?:

- Test ducting union and other duct component materials (tapes, silicones, bellows)
- Test fire retardant coatings
- Test new Kaowool board
- Complete testing by 2Q 2006
- Initiate AMOC Draft (By 4Q 2006)

Acknowledgement

BOEING

DAHER
AU SERVICE DU PROGRÈS INDUSTRIEL

degussa.
creating essentials

Flexfab

senior

Triumph Group, Inc.