

DOT/FAA/AR-00/12

Office of Aviation Research
Washington, D.C. 20591

Aircraft Materials Fire Test Handbook

April 2000

Final Report

This document is available to the U.S. public
through the National Technical Information
Service (NTIS), Springfield, Virginia 22161.



U.S. Department of Transportation
Federal Aviation Administration

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof. The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the objective of this report. This document does not constitute FAA certification policy. Consult your local FAA aircraft certification office as to its use.

This report is available at the Federal Aviation Administration William J. Hughes Technical Center's Full-Text Technical Reports page: www.actlibrary.tc.faa.gov in Adobe Acrobat portable document format (PDF).

1. Report No. DOT/FAA/AR-00/12		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle AIRCRAFT MATERIALS FIRE TEST HANDBOOK				5. Report Date April 2000	
				6. Performing Organization Code	
7. Author(s) Compiled by April Horner				8. Performing Organization Report No.	
9. Performing Organization Name and Address Federal Aviation Administration Fire Safety Section, AAR-422 William J. Hughes Technical Center Atlantic City International Airport New Jersey 08405				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Office of Aviation Research Washington, DC 20591				13. Type of Report and Period Covered Final Report	
				14. Sponsoring Agency Code ANM-100	
15. Supplementary Notes This handbook provides information supplemental to any presently available applicable Advisory Circulars. The FAA William J. Hughes Technical Center Monitor was Richard Hill.					
16. Abstract The purpose of the Aircraft Materials Fire Test Handbook is to describe all FAA-required fire test methods for aircraft materials in a consistent and detailed format. The handbook provides information to enable the user to assemble and properly use the test methods. Moreover, to broaden the utility of the handbook, the appendices contain the following information: FAA fire safety regulations, FAA approval process, aircraft materials, regulatory methodology used by other countries, aircraft industry internal test methods and guidelines, laboratories actively using fire test methods, and commercial manufacturers of fire test equipment.					
17. Key Words Fire Safety, Aircraft interior materials, Flammability			18. Distribution Statement This document is available to the public through the National Technical Information Service (NTIS) Springfield, Virginia 22161.		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 234	22. Price

CONTENTS

	Page
EXECUTIVE SUMMARY	xv
1.0 VERTICAL BUNSEN BURNER TEST FOR CABIN AND CARGO COMPARTMENT MATERIALS	1-1
1.1 Scope	1-1
1.2 Definitions	1-1
1.3 Test Apparatus	1-1
1.4 Test Specimens	1-4
1.5 Conditioning	1-4
1.6 Procedure	1-5
1.7 Report	1-6
1.8 Requirements	1-6
CHAPTER 1 SUPPLEMENT	1-7
2.0 45-DEGREE BUNSEN BURNER TEST FOR CARGO COMPARTMENT LINERS AND WASTE STOWAGE COMPARTMENT MATERIALS	2-1
2.1 Scope	2-1
2.2 Definitions	2-1
2.3 Test Apparatus	2-1
2.4 Test Specimens	2-4
2.5 Conditioning	2-5
2.6 Procedure	2-5
2.7 Report	2-6
2.8 Requirements	2-7
CHAPTER 2 SUPPLEMENT	2-8
3.0 HORIZONTAL BUNSEN BURNER TEST FOR CABIN, CARGO COMPARTMENT, AND MISCELLANEOUS MATERIALS	3-1
3.1 Scope	3-1
3.2 Definitions	3-1
3.3 Apparatus	3-1
3.4 Test Specimens	3-4
3.5 Conditioning	3-5
3.6 Procedure	3-5
3.7 Report	3-6
3.8 Requirements	3-6
CHAPTER 3 SUPPLEMENT	3-7
4.0 60-DEGREE BUNSEN BURNER TEST FOR ELECTRIC WIRE	4-1
4.1 Scope	4-1
4.2 Definitions	4-1
4.3 Apparatus	4-1
4.4 Test Specimens	4-3
4.5 Conditioning	4-3
4.6 Procedure	4-4
4.7 Report	4-4
4.8 Requirements	4-5
CHAPTER 4 SUPPLEMENT	4-6
5.0 HEAT RELEASE RATE TEST FOR CABIN MATERIALS	5-1
5.1 Scope	5-1
5.2 Definitions	5-1

	5.3	Test Apparatus	5-1
	5.4	Test Specimens	5-8
	5.5	Conditioning	5-8
	5.6	Calibration	5-9
	5.7	Test Procedure	5-10
	5.8	Report	5-11
	5.9	Requirements	5-11
		CHAPTER 5 SUPPLEMENT	5-12
6.0		SMOKE TEST FOR CABIN MATERIALS	6-1
	6.1	Scope	6-1
	6.2	Definitions	6-1
	6.3	Test Apparatus	6-1
	6.4	Test Specimen Selection and Preparation	6-10
	6.5	Specimen Conditioning	6-11
	6.6	Test Chamber Calibration	6-11
	6.7	Test Procedure	6-12
	6.8	Report	6-13
	6.9	Requirements	6-13
		CHAPTER 6 SUPPLEMENT	6-14
7.0		OIL BURNER TEST FOR SEAT CUSHIONS	7-1
	7.1	Scope	7-1
	7.2	Definitions	7-1
	7.3	Apparatus	7-1
	7.4	Test Specimens	7-6
	7.5	Specimen Conditioning	7-8
	7.6	Preparation of Apparatus	7-8
	7.7	Calibration	7-9
	7.8	Test Procedure	7-9
	7.9	Report	7-10
	7.10	Requirements	7-10
		CHAPTER 7 SUPPLEMENT	7-11
8.0		OIL BURNER TEST FOR CARGO LINERS	8-1
	8.1	Scope	8-1
	8.2	Definitions	8-1
	8.3	Apparatus	8-1
	8.4	Test Specimen(s)	8-6
	8.5	Specimen Conditioning	8-6
	8.6	Preparation of Apparatus	8-6
	8.7	Calibration	8-7
	8.8	Procedure	8-7
	8.9	Report	8-8
	8.10	Requirements	8-8
		CHAPTER 8 SUPPLEMENT	8-9
9.0		RADIANT HEAT TESTING OF EVACUATION SLIDES, RAMPS, AND RAFTS	9-1
	9.1	Scope	9-1
	9.2	Definition	9-1
	9.3	Test Apparatus	9-1
	9.4	Test Specimens	9-3
	9.5	Conditioning	9-3
	9.6	Calibration	9-3
	9.7	Procedure	9-4

	9.8 Report	9-4
	9.9 Requirement	9-4
	CHAPTER 9 SUPPLEMENT	9-5
10.0	FIRE CONTAINMENT TEST OF WASTE STOWAGE COMPARTMENTS	10-1
	10.1 Scope	10-1
	10.2 Definitions	10-1
	10.3 Test Apparatus/Equipment	10-2
	10.4 Test Unit	10-3
	10.5 Test Arrangements	10-3
	10.6 Procedure	10-4
	10.7 Report	10-6
	10.8 Requirements	10-7
	CHAPTER 10 SUPPLEMENT	10-8
11.0	POWERPLANT HOSE ASSEMBLIES TEST	11-1
	11.1 Scope	11-1
	11.2 Definitions	11-1
	11.3 Apparatus	11-1
	11.4 Test Specimens	11-10
	11.5 Calibration	11-10
	11.6 Procedure	11-11
	11.7 Report	11-12
	11.8 Requirements	11-12
	CHAPTER 11 SUPPLEMENT	11-13
12.0	POWERPLANT FIRE PENETRATION TEST	12-1
	12.1 Scope	12-1
	12.2 Definitions	12-1
	12.3 Apparatus	12-1
	12.4 Test Specimens	12-3
	12.5 Conditioning	12-3
	12.6 Calibration	12-3
	12.7 Procedure	12-4
	12.8 Report	12-4
	12.9 Requirements	12-5
	CHAPTER 12 SUPPLEMENT	12-6
13.0	TEST FOR ELECTRICAL CONNECTORS USED IN FIREWALLS	13-1
	13.1 Scope	13-1
	13.2 Definitions	13-1
	13.3 Apparatus	13-1
	13.4 Test Specimens	13-2
	13.5 Procedure	13-5
	13.6 Report	13-7
	13.7 Requirements	13-7
	CHAPTER 13 SUPPLEMENT	13-8
14.0	TEST FOR ELECTRICAL WIRE USED IN DESIGNATED FIRE ZONES	14-1
	14.1 Scope	14-1
	14.2 Definitions	14-1
	14.3 Apparatus	14-1
	14.4 Test Specimens	14-4
	14.5 Conditioning/Preparation of Test Specimens	14-4
	14.6 Calibration	14-5

	14.7 Procedure	14-5
	14.8 Report	14-6
	14.9 Requirements	14-7
	CHAPTER 14 SUPPLEMENT	14-8
15.0	TWO GALLON PER HOUR OIL BURNER CERTIFICATION TESTING FOR REPAIRED CARGO COMPARTMENT LINERS	15-1
	15.1 Scope	15-1
	15.2 Test Specimens	15-1
	15.3 Specimen Conditioning	15-3
	15.4 Procedure	15-3
	15.5 Report	15-4
	15.6 Requirements	15-5
16.0	RESERVED	16-1
17.0	RESERVED	17-1
18.0	RECOMMENDED PROCEDURE FOR THE 4-PLY HORIZONTAL FLAMMABILITY TEST FOR AIRCRAFT BLANKETS	18-1
	18.1 Scope	18-1
	18.2 Definitions	18-1
	18.3 Test Apparatus	18-1
	18.4 Test Specimens	18-4
	18.5 Conditioning	18-4
	18.6 Procedure	18-4
	18.7 Report	18-5
	18.8 Requirements	18-6
	CHAPTER 18 SUPPLEMENT	18-7
19.0	SMOKE TEST FOR INSULATED AIRCRAFT WIRE	19-1
	19.1 Scope	19-1
	19.2 Definitions	19-1
	19.3 Test Apparatus	19-1
	19.4 Test Specimen Selection and Preparation	19-10
	19.5 Test Chamber Calibration	19-12
	19.6 Procedure	19-13
	19.7 Report	19-14
	CHAPTER 19 SUPPLEMENT	19-15
20.0	DRY ARC TRACKING TEST PROCEDURE	20-1
	20.1 Purpose	20-1
	20.2 Test Specimens	20-1
	20.3 Procedure	20-2
	20.4 Report	20-2
21.0	DRY ARC-PROPAGATION RESISTANCE	21-1
	21.1 Purpose	21-1
	21.2 Test Equipment	21-1
	21.3 Test Samples	21-2
	21.4 Procedure	21-2
	21.5 Results	21-5
	21.6 Information Required in the Individual Specification	21-6
22.0	COTTON SWAB TEST FOR THERMAL ACOUSTIC INSULATION BLANKETS	22-1
	22.1 Scope	22-1
	22.2 Definitions	22-1

22.3	Test Apparatus	22-1
22.4	Test Specimens	22-1
22.5	Test Procedure	22-2
22.6	Report	22-2
22.7	Requirements	22-2
APPENDIX A: FAA REGULATIONS		A-1
A.1	A Brief History of Federal Agencies Regulating Aviation	A-1
A.2	Organization of the FAA	A-2
A.3	Enabling Legislation and Procedures for the FAA	A-4
A.4.	Documentary Sources for Flammability Requirements	A-8
APPENDIX B: THE APPROVAL PROCESS		B-1
B.1	Introduction	B-1
B.2	Approval Steps Manufacturers	B-1
B.3	Approval Steps—Operators	B-10
APPENDIX C: MATERIALS USED IN AIRCRAFT		C-1
C.1	Introduction	C-1
C.2	Aircraft Seats	C-1
C.3	Insulating Materials	C-2
C.4	Interior Panel Structures	C-3
C.5	Floor Coverings	C-5
C.6	Draperies	C-6
C.7	Nonmetallic Air Ducting	C-6
C.8	Linings (Nonpanel)	C-6
C.9	Electrical Components	C-7
C.10	Firewalls	C-7
C.11	Windows	C-7
C.12	Small Parts	C-8
APPENDIX D: REGULATORY METHODOLOGY USED BY OTHER COUNTRIES		D-1
D.1	Introduction	D-1
D.2	Foreign Airworthiness Authorities and Regulations	D-1
D.3	Regulations Covering Foreign Air Carriers	D-1
D.4	Certification of Foreign-Manufactured Aircraft	D-1
APPENDIX E: AIRCRAFT INDUSTRIES INTERNAL TEST METHODS AND GUIDELINES		E-1
APPENDIX F: LABORATORIES ACTIVELY USING FIRE TEST PROCEDURES		F-1
APPENDIX G: COMMERCIAL MANUFACTURERS OF FIRE TEST EQUIPMENT		G-1

LIST OF ILLUSTRATIONS

Figure		Page
1-1	Sketch of Vertical Bunsen Burner Test Cabinet	1-2
1-2	Front and Top View of Vertical Bunsen Burner Test Cabinet	1-2
1-3	Vertical Bunsen Burner Test Specimen Holder	1-3
1-4	Burner Plumbing and Burner Flame Height Indicator	1-3
1-5	Flame Position on Vertical Specimens	1-5
2-1	Sketch of 30-Second, 45-Degree Bunsen Burner Test Cabinet	2-2
2-2	Front and Top View of 30-Second, 45-Degree Bunsen Burner Test Cabinet	2-2
2-3	Side Views of 30-Second, 45-Degree Bunsen Burner Test Cabinet	2-3
2-4	30-Second, 45-Degree Bunsen Burner Test Specimen Frame and Stand	2-3
2-5	Burner Plumbing and Burner Flame Height Indicator	2-4
2-6	Flame Position on 30-Second, 45-Degree Bunsen Burner Test Specimen	2-6
3-1	Sketch of Horizontal Bunsen Burner Test Cabinet	3-1
3-2	Front and Top View of Horizontal Bunsen Burner Test Cabinet	3-2
3-3	Side View of Horizontal Bunsen Burner Test Cabinet	3-2
3-4	Horizontal Bunsen Burner Test Specimen Holder	3-3
3-5	Burner Plumbing and Burner Flame Height Indicator	3-4
3-6	Typical Burner and Specimen Location	3-5
4-1	60-Degree Electrical Wire Bunsen Burner Test Setup	4-2
4-2	Burner Plumbing and Burner Flame Height Indicator	4-3
4-3	Alternative Setup for 60-Degree Electrical Wire Bunsen Burner Test	4-7
5-1a	Rate of Heat Release Apparatus	5-2
5-1b	Rate of Heat Release Apparatus	5-3
5-2	Thermopile	5-4
5-3	Side View—Global Radiant Heat Panel	5-5
5-4	Heat Release Specimen Holder, Mounting Bracket, and Drip Pan	5-6
5-5	Lower Pilot Burner Igniter Schematic	5-7
5-6	Upper Pilot Burner - 15 Hole Burner	5-7
5-7	Typical Calibration Burner	5-9
6-1	Typical Smoke Density Chamber	6-1
6-2	Furnace Section	6-3
6-3	Heater Orientation	6-3
6-4	Alignment of Holder and Burner	6-4
6-5	Flame Size	6-5
6-6	Details of Specimen Holder	6-6
6-7	Typical Furnace Support	6-7
6-8	Photometer Detail	6-8
6-9	Photometer Location	6-9
6-10	Burner Position (Optional)	6-14

7-1	Front, Side, and Top Views of Seat Oil Burner Specimen Frame	7-2
7-2	Top and Side View of Specimen Setup in Test Frame	7-2
7-3a	Burner Cone Layout and Bending Pattern	7-3
7-3b	Burner and Cone Details	7-3
7-4	Illustration for the Location of the Air Velocity Sensor	7-4
7-5	Top and Side Views of Calorimeter Bracket	7-5
7-6	Top and Side Views of Thermocouple Rack Bracket	7-5
7-7	Example of Production Seat Configuration and Test Specimen Set to Substantiate Production Seat Bottom Cushion	7-7
7-8	Specimen Set to Substantiate Production Seat Bottom and Specimen Set to Substantiate Production Seat Back	7-7
7-9	Example of Production Seat Configuration Using Two Dress Cover Materials and Test Specimen Set to Substantiate Dress Cover Combination	7-8
7-10	Static Disk Illustration	7-13
8-1	Test Apparatus for Horizontal and Vertical Mounting for Cargo Liner Oil Burner Testing	8-1
8-2	Cargo Liner Test Specimen Frame	8-2
8-3	Cargo Liner Test Specimen Retaining Frame	8-2
8-4a	Burner Cone Layout and Bending Pattern	8-3
8-4b	Burner Cone Details	8-3
8-5	Top and Side Views of Calorimeter Bracket	8-4
8-6	Top and Side View of Thermocouple Rake Bracket	8-5
8-7	Illustration for the Location of the Air Velocity Sensor	8-6
8-8	Static Disk Illustration	8-10
9-1	Evacuation Slide Material Test Apparatus – Front View	9-1
9-2	Evacuation Slide Material Test Apparatus – Side View	9-2
9-3	Evacuation Slide Material Test Apparatus – Top View	9-2
9-4	Furnace Details	9-2
10-1	Sample Fire Containment Temperature versus Time Plot	10-6
11-1	Burner Extension Funnel	11-5
11-2	Air Tube Reducing Cone	11-5
11-3	Hose Assemblies Test Setup	11-6
11-4	Burner Calibration Standardization Apparatus	11-7
11-5	Btu Heat Transfer Device	11-7
11-6	Btu Heat Transfer Device—Reducer	11-7
11-7	Btu Heat Transfer Device—Inlet Tube	11-8
11-8	Btu Heat Transfer Device—Outlet Tube	11-8
11-9	Btu Heat Transfer Device—Thermometer Mounting	11-8
11-10	Btu Heat Transfer Device—Test Specimen	11-9
12-1	Firewall Penetration Test Setup—Top View	12-2
13-1	Firewall Connector Test Setup	13-3
13-2	Firewall Connector Fixture Assembly	13-4
13-3	Firewall Connector Fixture Details	13-5

13-4	Connector Electrical Integrity Connection Diagram	13-6
14-1	Firezone Electrical Wire Test Setup	14-2
14-2	Burner Details	14-3
14-3	Thermocouple Details	14-3
14-4	Fire Zone Electrical Wire Test Setup—Top View	14-5
14-5	Electrical Connections	14-6
15-1	Cargo Liner Test Specimen Frame	15-2
15-2	Eight- by Eight-Inch Patch Over Standard Damage	15-2
15-3	Overlapped Patches for Shingling Test	15-3
18-1	Sketch of Bunsen Burner Test Cabinet	18-1
18-2	Front and Top View of Bunsen Burner Test Cabinet	18-2
18-3	Side Views of Bunsen Burner Test Cabinet	18-2
18-4	Horizontal Test Fixture	18-3
18-5	Burner Plumbing and Burner Flame Height Indicator	18-3
18-6	Horizontal Test Fixture with Four-Ply Blanket Sample	18-5
19-1	Typical Smoke Density Chamber	19-1
19-2	Furnace Section	19-3
19-3	Heater Orientation	19-3
19-4	Straight Tip Burner	19-4
19-5	Alignment of Holder and Burner	19-5
19-6	Flame Size	19-5
19-7	Details of Specimen Holder	19-6
19-8	Typical Furnace Support	19-7
19-9	Photometer Detail	19-8
19-10	Optical System Location Plan View	19-9
19-11	Wire Holding Frame	19-11
19-12	Larger Gauge Wire Mounted in Specimen Holder	19-11
20-1	Wire Bundle Configuration	20-1
20-2	Electrical Connections	20-2
21-1	Typical Abrader Blade	21-1
21-2	Aluminum Blade Sharpening Fixture	21-2
21-3	Bundle Configuration	21-3
21-4	Test Fixture	21-3
21-5	Electrical Connection	21-4
21-6	Ball-Slide Blade Fixture	21-5
22-1	Cotton Swab Test Configuration	22-2

LIST OF TABLES

Tables	Page
1-1	1-8
4-1	4-2
10-1	10-1
11-1	11-2
11-2	11-11
13-1	13-6
14-1	14-4
21-1	21-4
21-2	21-4

LIST OF ACRONYMS

A	Ampere(s)
AC	Advisory Circular
AC	Alternating Current
ACD	Aircraft Certification Directorate/Division
ACO	Aircraft Certification Office
AD	Airworthiness Directive
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
AWG	American Wire Gauge
BAA	Bilateral Airworthiness Agreement
BCAR	British Civil Airworthiness Requirement
Btu	British Thermal Unit
C	Centigrade
CAA	Civil Aeronautics Administration
CAB	Civil Aeronautics Board
CAMI	Civil Aeromedical Institute
CAR	Civil Air Regulation
CC	Constant Capacity
CFR	Code of Federal Regulations
CL	Center Line
cm	Centimeter(s)
DC	Direct Current
DER	Designated Engineering Representative
DMIR	Designated Manufacturing Inspection Representative
DOT	Department of Transportation
D_s	Specific Optical Density
F	Fahrenheit
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
Fe(CO) ₅	Iron pentacarbonyl

FPM	Feet per Minute
FR	Fire-Retarded
FR	Flame Retardant
FSS	Flight Standards Service
FSSR	Flight Standards Service Release
g	Gram(s)
GENOT	General Notice
H ₂ O	Water
Hg	Mercury
HP	Horsepower
Hz	Hertz
ICAO	International Civil Aviation Organization
ID	Inside Diameter
JAR	Joint Airworthiness Regulation
K	Kelvin
kPa	Kilo Pascal(s)
Kv	Kilovolt(s)
kVA	Kilovolt Ampere(s)
kW	Kilowatt(s)
L	Liter
m	Meter
MIDO	Manufacturing Inspection District Office
mil	Milliliter
mm	Millimeter(s)
MPa	Mega Pascal(s)
MPS	Meters per Second
mV	Millivolt(s)
NBS	National Bureau of Standards
NF	National Fine
NIST	National Institute of Standards and Technology
NPRM	Notice of Proposed Rulemaking
NPT	Normal Pressure and Temperature
OD	Outside Diameter
OEM	Original Equipment Manufacturer
PATCO	Professional Air Traffic Controllers Organization
PI	Principal Investigator
PMA	Part Manufacturer Approval
psi	Pounds per Square Inch
psig	Pounds per Square Inch—Gauge
PTFE	Polyethylenetetrafluoroethylene
PVF	Polyvinyl Fluoride
S	Second
SAE	Society of Automotive Engineers
SRR	Safety Regulation Release

STC	Supplemental Type Certificate
STP	Standard Temperature and Pressure
TC	Type Certificate
THD	Thread
TSO	Technical Standard Order
UV	Ultraviolet
V	Volt
W	Watt(s)

EXECUTIVE SUMMARY

In order to assure prescribed levels of fire safety in civil aircraft, the Federal Aviation Administration (FAA) requires that a variety of fire test methods be used to demonstrate that aircraft materials meet specified performance criteria when exposed to heat or flame. In principle, the specific test method required serves as a surrogate for the fire environment to which a given material could potentially be exposed, and the test criteria relate to the performance of the material in this fire environment. This handbook provides information supplemental to any presently available applicable Advisory Circulars.

While a number of fire test requirements are of recent vintage, others have origins in research and development efforts completed many years ago. Because of a span of time during which the various fire test requirements were developed, there is an inevitable wide variation in the accessibility of primary technical documents, in currency of test equipment details, and in style and clarity of technical content.

The purpose of the *Aircraft Materials Fire Test Handbook* is to describe all FAA-required fire test methods for aircraft materials in a consistent and detailed format. The handbook provides information to enable the user to assemble and properly use the test methods. Moreover, to broaden the utility of the handbook, the appendices contain the following information: FAA fire safety regulations, FAA approval process, aircraft materials, regulatory methodology used by other countries, aircraft industry internal test methods and guidelines, laboratories actively using fire test methods, and commercial manufacturers of fire test equipment.

Chapter 1

Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials

1.1 Scope

This test method is intended for use in determining the resistance of materials to flame when tested according to the 60-second and 12-second Vertical Bunsen Burner Tests specified in Federal Aviation Regulation (FAR) 25.853 and FAR 25.855.

1.2 Definitions

1.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. It can be either 60 seconds or 12 seconds for this test.

1.2.2 Flame Time

Flame time is the time in seconds that the specimen continues to flame after the burner flame is removed from beneath the specimen. Surface burning that results in a glow but not in a flame is not included.

1.2.3 Drip Flame Time

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the specimen to the floor of the chamber. If no material falls from the specimen, the drip flame time is reported to be 0 seconds, and the notation “No Drip” is also reported. If there is more than one drip, the drip flame time reported is that of the longest flaming drip. If succeeding flaming drips reignite earlier drips that flamed, the drip flame time reported is the total of all flaming drips.

1.2.4 Burn Length

Burn length is the distance from the original specimen edge to the farthest evidence of damage to the test specimen due to that area’s combustion including areas of partial consumption, charring, or embrittlement but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat.

1.3 Test Apparatus

1.3.1 Test Cabinet

Tests will be conducted in a draft-free cabinet fabricated in accordance with figures 1-1 to 1-3 or other equivalent enclosures acceptable to the Federal Aviation Administration (FAA). It is suggested that the cabinet be located inside an exhaust hood to facilitate clearing the cabinet of smoke after each test. Stainless steel or other corrosion-resistant metal 0.04 inch (1 mm) thick will be used for the bottom surface of the chamber.

1.3.2 Specimen Holder

The specimen holder will be fabricated of corrosion-resistant metal in accordance with figure 1-3 or the equivalent. The holder will be able to accommodate specimens up to 1 inch (25 mm) thick.

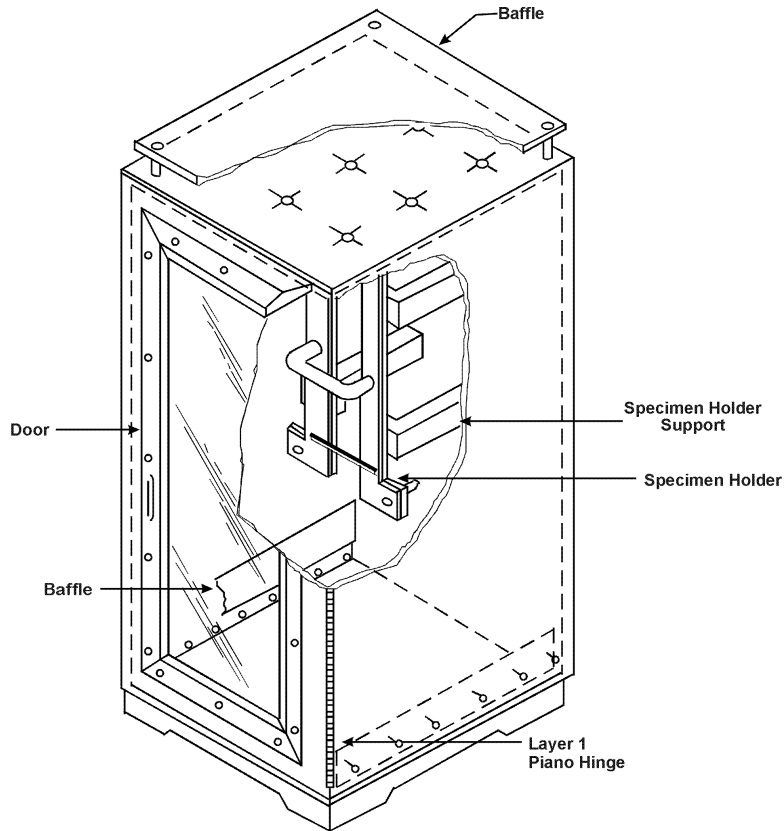


Figure 1-1. Sketch of Vertical Bunsen Burner Test Cabinet

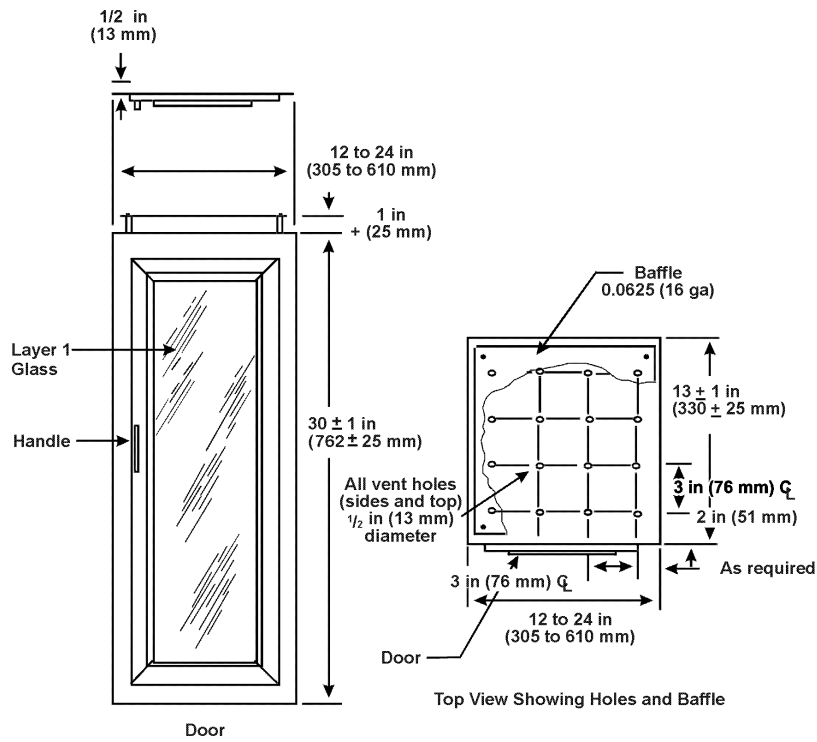


Figure 1-2. Front and Top View of Vertical Bunsen Burner Test Cabinet

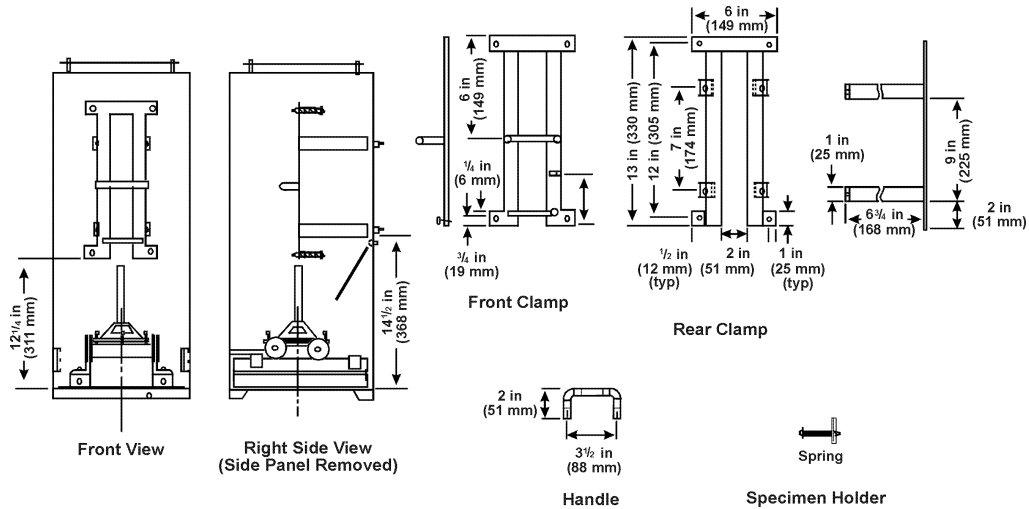


Figure 1-3. Vertical Bunsen Burner Test Specimen Holder

1.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 3/8-inch (10-mm) inside diameter barrel, and be equipped with a needle valve located at the bottom of the burner barrel to adjust the gas flow rate and, thereby, adjust the flame height. There will be a means provided to move the burner into and out of test position when the cabinet door is closed.

1.3.3.1 Burner Fuel

Methane gas (99 percent minimum purity) or other burner fuel acceptable to the FAA will be used. Methane is the preferred fuel. It can be used without adding air through the aspirating holes at the bottom of the burner barrel; e.g., a pure diffusion flame may be used.

1.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure 1-4. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of $2 \frac{1}{2} \pm \frac{1}{4}$ psi (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

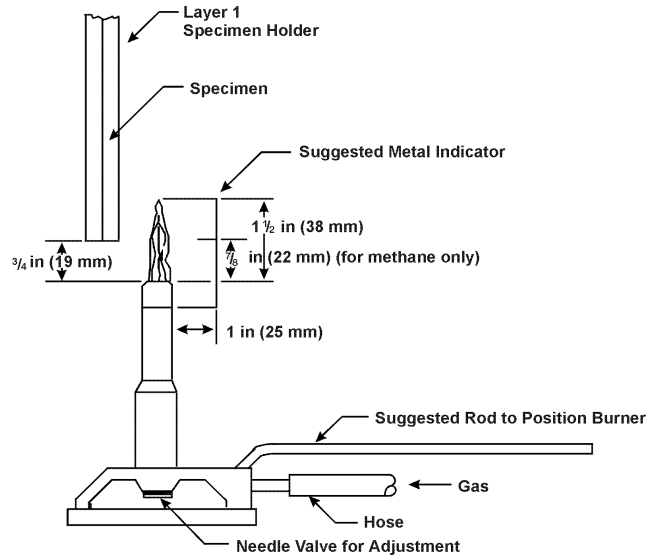


Figure 1-4. Burner Plumbing and Burner Flame Height Indicator

1.3.3.3 Flame Height Indicator

A flame height indicator may be used to aid in setting the height of the flame. A suitable indicator has a prong extending 1.5 inches (38 mm) above the top of the burner barrel, is attached to the burner barrel, and spaced 1 inch (25 mm) from the burner barrel, as shown in figure 1-4. If using methane as the burner fuel, it is desirable to have two prongs for measuring the flame height, one prong to indicate the height of the inner cone of the flame and one prong to indicate the height of the tip of the flame. For methane, it has been determined that when the height of the inner cone is 7/8 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long, the proper flame profile is achieved.

1.3.4 Timer

A stopwatch or other device, calibrated to the nearest 0.1 second, will be used to measure the time of application of the burner flame, the flame time, and the drip flame time.

1.3.5 Ruler

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) will be provided to measure the burn length.

1.4 Test Specimens

1.4.1 Specimen Selection

Specimens tested will be either cut from a fabricated part as installed in the aircraft or cut from a section simulating a fabricated part, e.g., cut from a flat sheet of material or from a model of the fabricated part. The specimen may be cut from any location in the fabricated part. However, the edge to which the burner is applied must not consist of the finished or protected edge of the specimen. Fabricated units, such as sandwich panels, will not be separated into individual component layers for testing.

1.4.1.1 For parts that may have different flammability characteristics in different directions (e.g., textiles), separate sets of specimens, cut from each direction showing the greatest difference (e.g., warp and fill), will be provided and tested.

1.4.2 Specimen Number

Each separate set of specimens prepared for testing will consist of at least three specimens (multiple places).

1.4.3 Specimen Size

The specimen will be a rectangle at least 3 by 12 inches (75 by 305 mm), unless the actual size used in the aircraft is smaller.

1.4.4 Specimen Thickness

The specimen thickness will be the same as that of the part qualified for use in the airplane, with the following exceptions:

1.4.4.1 If the part construction is used in several thicknesses, the minimum thickness will be tested.

1.4.4.2 Foam parts that are thicker than 1/2 inch (13 mm), such as seat cushions, will be tested in 1/2-inch (13-mm) thicknesses.

1.4.4.3 Parts that are smaller than the size of a specimen and cannot have specimens cut from them may be tested using a flat sheet of the material used to fabricate the part in the actual thickness used in the aircraft.

1.5 Conditioning

Specimens will be conditioned at $70^{\circ} \pm 5^{\circ}\text{F}$ ($21^{\circ} \pm 3^{\circ}\text{C}$) and $50\% \pm 5\%$ relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before testing.

1.6 Procedure

1.6.1 Burner Adjustment

- 1.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.
- 1.6.1.2 Open the stopcock in the gas line fully and light the burner.
- 1.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height, in accordance with section 1.3.3.3.

1.6.2 Test Procedure

- 1.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.
- 1.6.2.2 Insert the specimen with its lower edge $\frac{3}{4}$ inch (19 mm) above the level of the top of the burner.
- 1.6.2.3 Close the cabinet door, and keep it closed during the test.
- 1.6.2.4 Start the timer immediately upon positioning the burner. Position the burner so that the flame impinges on the midpoint of the lower edge of the front face of the test specimen. This flame position should be used for all specimen thicknesses (see figure 1-5).

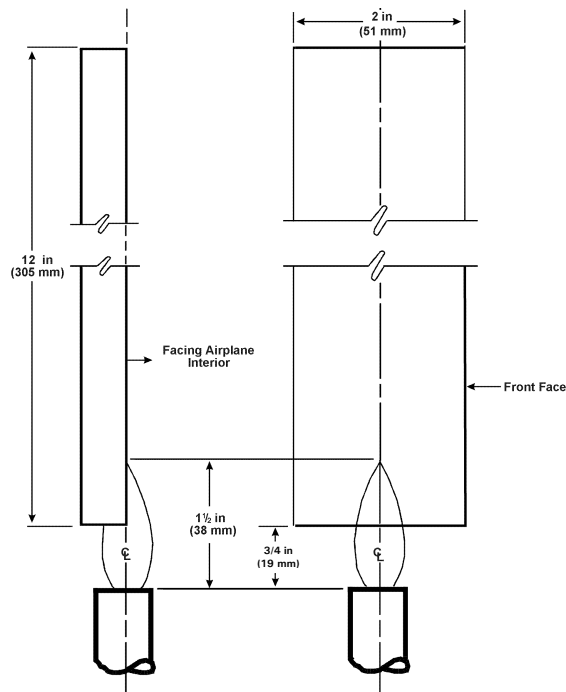


Figure 1-5. Flame Position on Vertical Specimens

- 1.6.2.5 Apply the flame for 12 seconds or 60 seconds, as appropriate, and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off.
- 1.6.2.6 If flaming material falls from the test specimen, determine the drip flame time for the specimen.
- 1.6.2.7 Determine the flame time for the specimen.

- 1.6.2.8 After all flaming ceases, open the cabinet door slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing smoke and fumes.
- 1.6.2.9 Remove the specimen and determine the burn length. To aid in determining the burn length, a dry soft cloth or tissue, or a soft cloth or tissue dampened with a moderate solvent, such as methyl, ethyl, or isopropyl alcohol (which does not dissolve or attack the specimen material), may be used to remove soot and stain particles from tested specimens.
- 1.6.2.10 Remove any material from the bottom of the cabinet that fell from the specimen. If necessary, clean the test cabinet window and/or back face mirror prior to testing the next specimen.

1.7 Report

1.7.1 Material Identification

Fully identify the material tested, including thickness. Also, include the specimen length if a 12-inch specimen is not available.

1.7.2 Test Results

1.7.2.1 Ignition Time

Report whether the ignition time was 12 seconds or 60 seconds.

1.7.2.2 Flame Time

Report the flame time for each specimen tested. Determine and record the average value for flame time (see section 1.2.2).

1.7.2.3 Drip Flame Time

Report the drip flame time for each specimen tested. Determine and record the average value for the drip flame time (see section 1.2.3). For specimens that have no drips, record "0" for the drip flame time and also record "No Drips."

1.7.2.4 Burn Length

Report the burn length to the nearest 0.1 inch for each specimen tested. Determine and record the average value for burn length.

1.8 Requirements

1.8.1 Flame Time

The average flame time for all of the specimens tested will not exceed 15 seconds for either the 12-second or the 60-second vertical test.

1.8.2 Drip Flame Time

The average drip extinguishing time for all of the specimens tested will not exceed 3 seconds for the 60-second vertical test or 5 seconds for the 12-second vertical test.

1.8.3 Burn Length

The average burn length for all of the specimens tested will not exceed 6 inches (152 mm) for the 60-second vertical test or 8 inches (203 mm) for the 12-second vertical test.

Chapter 1 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

1.2.1 Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

1.2.4 This definition of burn length is a clarification of that used in FAR 25, Appendix F, Part I, viz.: “Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat source.” The main point is that “damage to the test specimen due to flame impingement” is clarified by “damage to the test specimen due to that area’s combustion” because it is a better description of the intent of the rule and is consistent with current test practices.

The burn length definition specified in FAR 25, Appendix F, applies to all materials listed in Part 25.853 and FAR 25.855. Since such a wide variety of materials require vertical Bunsen burner testing, areas that might obviously be included as burn length in some materials may not always be as well defined in others.

While burn lengths of materials used in modern aircraft interiors generally fall well below the 6-inch (60-second) or 8-inch (12-second) maximum limit, it is beneficial to develop criteria for those materials that occasionally approach the pass/fail limit.

For the most part, these materials may be divided into four general categories; they are polymeric materials (such as panels, partitions, transparencies, etc., which may be hybrid or single plastic material), textiles, carpeting, and foams.

The following methods have been suggested for determining burn length:

- a. **Polymeric Materials.** In order to fix the boundary where the flame front was impinging on the specimen surface and damaging the specimen due to that area’s combustion, i.e., below which combustion of the specimen occurred and above which it did not, it is necessary to observe the specimen continuously during the test. Flame impingement on the specimen may lead to outgassing due to thermal decomposition. As these gases burn, radiating heat may cause discoloration, sooting, staining, melting, etc., to areas above the flame front. This type of damage is not a result of thermal decomposition due to flaming and, therefore, would not be included in the burn length.
- b. **Textiles.** Burn length may be determined by using weights as specified in Test Method 5903.1, “Flame Resistance of Cloth, Vertical” (12/28/87) as follows:

After removing the specimen from the test cabinet, allow the specimen to cool and then measure the burn length. The burn length is the distance from the end of the specimen, which was exposed to the flame, to the top of the lengthwise tear made through the center of the charred area. Fold the specimen lengthwise and crease it by hand along a line through the highest peak of the charred area. Insert the hook into the specimen (or insert it into a hole, 1/4 inch (6 mm) in diameter or less) at one side of the charred area 1/4 inch (6 mm) in from the lower end. Attach a weight to the hook of sufficient size (that the weight and hook together equal the total tearing load required shown in table 1).

Gently apply a tearing force to the specimen by grasping the corner of the cloth at the opposite edge of the char from the load and raising the specimen and weight clear of the supporting surface. Raise the specimen in one smooth continuous motion; do not jerk or pull the specimen forcefully upward. Mark the end of the tear on the edge of the specimen and take the char length measurement along the undamaged edge.

- c. **Carpeting.** Tear the specimen with your hands. Use only enough force to tear the charred material. Stop when the fabric does not give way freely.

- d. Polyurethane Foams. Polyurethane foams are cellular in nature and, therefore, have low thermal conductivity. Since high surface temperatures are generated on exposure to the burner flame, an almost instantaneous conversion to flammable gases results. This, in turn, produces rapid surface flame spread with complete consumption of the foam immediately above the ignition source. By definition, complete consumption of an area is part of the burn length and should be included.

Table 1-1. Loads for Determining Char Length

The specific load applicable to the weight of the test cloth should be as follows:			
Specified weight per square yard of cloth before any fire retardant treatment or coating		The tearing weight for determining the charred length	
Ounces per square yard	g/m²	Pounds	kg
2.0 to 6.0	68 to 203	0.25	0.1
Over 6.0 to 15.0	Over 203 to 508	0.5	0.2
Over 15.0 to 23.0	Over 508 to 780	0.75	0.3
Over 23.0	Over 780	1.0	0.45

1.3.1 Suitable test cabinets of the type described are manufactured by the U.S. Testing Co., 1415 Park Ave., Hoboken, New Jersey 07030; Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, Illinois 60613; and The Govmark Organization, Inc., P.O. Box 807, Bellmore, New York 11710.

Draft free implies a condition of no air currents in a closed in space. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lighted cigarette, in the test cabinet, then closing the door and observing the behavior of the smoke for signs of drafts. A test cabinet other than one fabricated in accordance with figures 1-1 to 1-3 may be found to be acceptable after review by the FAA.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing of the test specimen, and a mirror may be located on the inside back surface to facilitate observation of the hidden surfaces.

1.3.3 A suitable burner is available from Rascher & Betzold Inc., 5410 N. Damen Ave., Chicago, Illinois 60625, Catalog No. R3726A.

1.3.3.1 Gases such as natural gas and propane can be used as burner fuel. However, it should be required to show compliance with the 1550°F minimum flame temperature using a 24 American Wire Gauge (AWG) thermocouple.

B-gas, which is the burner fuel specified in Federal Test Method Standard 5903, meets minimum temperature requirements and is still used in some laboratories. However, its use has resulted in problems and is not recommended. See note below for more details.

NOTE: B-gas, a mixture of 55 percent hydrogen, 18 percent carbon monoxide, 24 percent methane, and 3 percent ethane, has shown inconsistent burning characteristics in steel cylinders. A “spike” of varying intensity is produced. It has been postulated that the carbon monoxide in the gas may react with the iron in the steel cylinders to produce iron pentacarbonyl (Fe(CO)₅), which is volatile and may cause interference with the normal flame characteristics and may be the cause of the erratic behavior. Because of the inconsistent flame characteristics, B-gas, at least if supplied in steel cylinders, is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

A phenomenon that some labs have experienced is a sharp decrease in flame temperature after about three-fourths of the gas originally in the cylinder has been used. This has occurred primarily in labs that have single-stage regulators on their gas cylinders. Single-stage regulators differ from two-stage regulators in that control of the discharge pressure is not as accurate. Few designs should maintain constant or near constant discharge pressures over the full range of cylinder pressures. Therefore, it is necessary to make adjustments periodically to allow for decreasing inlet pressures. Even the slightest drop in pressure should affect the flow rate of gas through the burner orifice. This, in

turn, should cause temperature variation. By using a two-stage regulator or adjusting pressure on a single-stage regulator, as the cylinder gets low, this problem can essentially be eliminated.

1.3.3.3 The tip of the methane flame is blue, transparent, and difficult to see. It is more easily seen if there is no light on the flame, as in a darkened room. The inner cone of the flame is, however, more visible and easily seen and can be used to monitor flame height. When the flame height (blue transparent tip) is set to 1.5 inches, the height of the inner cone has been found to vary slightly from burner to burner, but is generally about 7/8 inch. Therefore, if the inner cone height is used to monitor flame height, the inner cone height needs to be established for that burner.

1.4.1 Currently, the most commonly used specimens are thermal/acoustic insulation blankets consisting of fiberglass insulation with scrimmed film cover. Appendix F to FAR Part 25 states that materials must be tested either as a section cut from a fabricated part as installed in the airplane or as a specimen simulating a cut section. Therefore, it is by regulation mandated that the insulation blanket be tested as a finished product (insulation and film cover together). Appendix F also states that the edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen, but must be representative of the actual cross-section of the material or part installed in the airplane. Therefore, a 3- by 12-inch section of the blanket for vertical testing should be cut from the interior and must not include an enclosed edge.

1.4.3 By regulation, there must be at least 2 inches of the specimen exposed; however, the text specifies a specimen cut 3 inches in width. This allows enough material to ensure that the specimen is securely held in the holder. From experience, it has been found that materials such as textiles and films are difficult to secure in the holder and, therefore, may be cut even greater than 3 inches in width. This allows the operator adequate material to pull or adjust so that the specimen does not buckle or fall out of the holder.

1.4.4 According to the FAR 25.853, the specimen thickness must be no thicker than the minimum thickness to be qualified for use in the airplane. If the test facility has found from experience or has questions concerning the flammability of a thicker specimen, then vertical testing may be conducted and test data recorded for further review.

1.5 As stated in the FAR 25.853, only one specimen may be removed at a time from the conditioning chamber prior to being subjected to the flame. Some facilities, however, have conditioning chambers located in areas remote from the testing area. In this case, it is permissible to remove more than one specimen at a time only if each specimen is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination such as dirty lab tops, soot in the air, etc., until the specimen is subjected to the flame.

1.6.2.2 Inserting the standard sized 3-inch (76-mm) -thick thermal/acoustic insulation test specimen into the Bunsen burner holder results in extreme compression of the blanket on the sides and an elliptical section on the bottom center. This configuration may compromise test results. The recommended method is to mount the specimen on the front face of the holder and use safety wire to secure it in place. It has been found that two pieces of safety wire, one wrapped around the 10-inch point and one wrapped around the 6-inch point, keep the sample flat and in place.

1.6.2.3 It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

1.6.2.4 More information is available in DOT/FAA/CT-86/22, "An Investigation of the FAA Vertical Bunsen Burner Flammability Test Method." Appendix F, FAR 25.853, Part I describes this test and specifies that the flame be placed "along the centerline of the lower edge." The "centerline of the lower edge" is the line from the front face to the back face of the specimen. For thicker specimens, this is ambiguous since exactly "where" along the "centerline of the lower edge" is not specified.

Historically, test practices regarding burner flame placement have not been uniform or consistent within either the FAA or aircraft manufacturers. The most common placement used in the past was specified in the original issue of this handbook, viz.:

For specimens that are 3/4 inch (19 mm) thick or less, place the burner barrel centerline under the center of the bottom surface of the specimen.

For specimens thicker than 3/4 inch (19 mm), center the burner barrel under the bottom surface of the specimen 3/8 inch (10 mm) in from the surface exposed to the airplane interior, test each surface separately unless the surfaces are of the same materials and construction.

Another placement that has been less commonly used is that specified here, viz., directly under the middle of the lower edge of the face of the specimen that is exposed to the airplane interior. For specimens thinner than the burner barrel thickness (3/8 inch; 10 mm), test results are relatively insensitive to exactly where “along the centerline of the lower edge” the burner flame is placed. For samples of greater thickness, however, burn lengths are typically an inch or so longer if the burner barrel centerline is placed under or near the specimen face, and flame times are sometimes a little longer than if the flame is placed per the original handbook, Report DOT/FAA/CT-89/15, September 1990.

Materials used in contemporary (especially postheat release) designs produce burn lengths and flame times that are considerably less than the acceptance criteria for certification (6 inches and 15 seconds), regardless of where the flame is placed. Although where the burner flame is applied is not of important pass/fail significance in this test, placing it directly under the specimen face generally represents a worst-case situation.

The FAA should accept data for certification using the flame placement described in the original portion of this handbook, or using the flame placed under the exposed face of the test specimen. However, the FAA and aircraft manufacturers have agreed that in the future, the preferred placement of the burner flame is under the middle of the lower edge of the face of the specimen.

1.6.2.5 If the burner extinguishes during the ignition time for any reason, rerun the test. From experience, it has been found that this is a necessary requirement when running a 12-second test. However, experience has also shown that if the flame extinguishes during a 60-second test, the test is not compromised by relighting the flame up to three times and adding up the ignition times. If the flame does extinguish, the flame must be relighted immediately. Failure to do so could result in the specimen cooling and compromising test results. The opposite end of the same specimen can be used for the retest if the burn length for the aborted test is less than 3 inches (76 mm). If the burn length for the aborted test is greater than 3 inches (76 mm), a new specimen must be used.

1.6.2.8 The operator should refer to the facility’s safety manual for further information on dealing with smoke and flammability by-products.