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William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

Aircraft Materials Fire Test Handbook, Revision 3

July 2019

Interim Report

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16. Abstract

The FAA has published two previous versions of the Aircraft Materials Fire Test Handbook: DOT/FAA/CT-89/15 and DOT/FAA/AR-00/12. The main purpose of the Handbook is to describe various 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 certain test methods. The FAA adopted policy that made the first two versions of the Handbook an acceptable method of compliance for certain requirements in 14 Code of Federal Regulations (CFR) Part 25. This third-generation Handbook supports an FAA effort to revise the flammability requirements for Transport Category Airplanes in 14 CFR Part 25.

This Handbook organizes the test methods according to the threat posed by the material and its function. It describes various types of flammability tests in a consistent and detailed manner, and provides information to help the user assemble, operate, and use the test methods. Appendices contain additional information to broaden the utility of the Handbook.

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LIST OF ACRONYMS

AC	Alternating current
AC	Advisory Circular
ACOs	Aircraft Certification Offices
AD	Airworthiness Directive
AHRR	Actual heat release rate
AISI	American Iron and Steel Institute
ARAC	Aviation Rulemaking Advisory Committee
ASTM	American Society of Testing and Materials
AWG	American Wire Gauge
CAA	Civil Aeronautics Administration
CAMI	Civil Aeromedical Institute
CAR	Civil Air Regulation
CFR	Code of Federal Regulations
CHRR	Corrected heat release rate
CHZ	Central hot zone
CP	Certified purity
DC	Direct current
FR	Flame retardant
FSSR	Flight Standards Service Release
HFG	Heat-flux gauge
HHV	Higher heating value
HV	Heating Value
HSI	Hot surface igniter
ID	Inside diameter
LHV	Lower heating value
MFC	Mass flow controllers
MFWG	Materials Flammability Working Group
MIDOs	Manufacturing Inspection District Offices
MOC	Means of compliance
NIST	National Institute of Standards and Technology
NPRM	Notice of Proposed Rulemaking
NPT	National Pipe Thread
OD	Outside diameter
OEM	Original equipment manufacturer
SAE	Society of Automotive Engineers
SCFM	Standard cubic feet per minute
SLPM	Standard liter per minute
SRR	Safety Regulation Release
STP	Standard temperature and pressure
THRR	Total heat release rate
TSO	Technical Standard Order
TST	Thermal stability temperature
VFP	Vertical flame propagation

EXECUTIVE SUMMARY

FAA report DOT/FAA/AR-00/42, Aircraft Materials Fire Test Handbook, was published to capture updates and improvements to methods to comply with the testing requirements in appendix F of title 14, Code of Federal Regulations (14 CFR) part 25, and to provide general information to the public on aviation fire safety. The Handbook was incorporated into FAA policy by Policy Statement ANM-01-01, Use of the Aircraft Materials Fire Test Handbook, on February 22, 2001. The organization of this Handbook is patterned from the recommendation of an FAA advisory committee to structure flammability testing methods and requirements according to the type of threat presented by the material and its function. This Handbook is therefore a compendium of various flammability tests, organized according to threat, and presented in a consistent yet detailed manner. The Handbook is intended to provide information that will enable a user to assemble, operate, and use the various test methods and apparatus.

Although none of the test methods described are requirements themselves, there are requirements within the context of a specific test method to correctly perform the test. When one of the test methods in this Handbook is used as a method of compliance with a regulatory requirement, any deviations from the test methods in the Handbook would indicate a new method of compliance.

In addition, appendices are included that contain information to broaden the utility of the Handbook. The appendices list laboratories actively using fire test methods and commercial manufacturers of fire test equipment.

1. INTRODUCTION

1.1 PURPOSE

The purpose of this Handbook is to provide a compendium of flammability tests that can be used to meet the design standards for transport category airplanes in 14 CFR part 25.

1.2 BACKGROUND

The flammability requirements for interior materials on transport category airplanes have evolved significantly over the years. As the FAA and industry gained experience with various test methods, the FAA made improvements to the test equipment and procedures, which were captured in earlier versions of the Handbook. To take advantage of these improvements, the Handbook was incorporated into FAA policy by Policy Statement ANM-01-01, "Use of the Aircraft Materials Fire Test Handbook" (Feb. 22, 2001).

For various reasons (e.g., multiple requirements applying to the same component; conflicting requirements for the same component depending on the material from which it is made; and ambiguous requirements for components not explicitly listed in § 25.853 or part I of appendix F to part 25) the FAA considered whether organizing requirements on the basis of fire threat would be more effective. This approach would simplify compliance demonstrations and upgrade the level of safety for flammability throughout the airplane.

On August 27, 2010, the FAA issued a Notice of New Task Assignment to the Aviation Rulemaking Advisory Committee (ARAC) to review the merits of a threat-based approach. The new task assigned the ARAC to review and submit recommendations regarding how the FAA could update, reorganize, and improve the level of safety of requirements for the flammability of materials.

1.3 ARAC ACTIVITY

As a result of this notice, a new Materials Flammability Working Group (MFWG) was established under the ARAC's Transport Airplane and Engine Issues subcommittee to support this task. One of the key recommendations of the MFWG was the need for well-defined test methods to support compliance with the proposed requirements. The MFWG also recommended that the FAA organize its requirements according to the type of threat.

2. DISCUSSION

Appendix F at amendment 25-128 is divided into seven parts, with each part defining different required test methods. A new part has been added to appendix F because the regulations were amended to include new requirements. The structure is therefore chronological, and not related to the content of the test method. One objective is to organize test methods according to the type of threat the test methods represent. As defined in table 1, this threat is either in-flight or post-crash.

Table 1. Fire threats and corresponding threat representations

Type of Threat	Threat Representation	Test Method	Appendix F at Amendment 25-138 Part
In-flight (cabin)	Flaming foam block	Radiant panel	VI
In-flight (cargo)	Cardboard box fire	Oil burner	III
In-flight/Post-crash	Pan fire/gasoline	Oil burner	II
Post-crash	Pan fire	OSU/NBS	IV and V
Post-crash	Pan fire	Oil burner	VII
N/A	Arc/spark?	Bunsen burner	I
Post-crash	Pan fire	Oil burner	N/A

Definitions from table 1:

Type of Threat is either in-flight or post-crash.

Threat Representation is how the FAA has tested at a large scale to quantify the issues.

Test Method is the way the threat representation gets translated into certification standards; note that some methods have different detailed parameters depending on the affected parts.

Current Appendix F Part is simply which part of appendix F covers the test method currently.

3. FLAMMABILITY HANDBOOK LAYOUT

A compendium of various flammability tests for interior materials is assembled organized into five chapters:

Chapter A: Flammability tests based on a post-crash fire threat

Chapter B: Flammability tests based on a cabin in-flight fire threat

Chapter C: Flammability tests based on a cargo compartment in-flight fire threat

Chapter D: Other flammability tests

Chapter E: Powerplant flammability tests

In addition to the 5 chapters, 14 appendices (alphabetically A–N) are also included to broaden the utility of the compendium. The appendices contain the following information: laboratories actively using fire test methods, commercial manufacturers of fire test equipment, and detailed descriptions of the various test apparatuses.

CHAPTER A: FLAMMABILITY TESTS BASED ON A POST-CRASH FIRE THREAT

Chapter A1
Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials

A1.1 Scope

A1.1.1 Applicability

This test method evaluates the resistance of materials to flame when tested according to the 12-second or 60-second Vertical Bunsen Burner Test specified in 14 CFR 25.853 and 25.855.

A1.2 Definitions

A1.2.1 Ignition Time

Ignition time is either 12 or 60 seconds and is the length of time the burner flame is applied to the sample. The ignition time should start only after the flame has stabilized and is properly positioned under the test sample.

A1.2.2 Flame Time

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

A1.2.3 Drip Flame Time

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the sample to the floor of the chamber. If no material falls from the sample, 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.

A1.2.4 Burn Length

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

A1.3 Test Apparatus

A1.3.1 Test Cabinet

Tests must be conducted in a draft-free cabinet or other enclosure acceptable to the FAA. The test cabinet must have a viewing window set up such that both sides of the sample can be observed during testing. Using a mirror to observe the back of the sample is allowed. It is suggested that the cabinet be located inside an exhaust hood to facilitate clearing the cabinet of smoke after each test. Refer to appendix I for more details on the test cabinet.

A1.3.2 Sample Holder

The sample holder must be fabricated of corrosion-resistant metal in accordance with figure A1-1 or the equivalent. The holder must be able to accommodate samples up to 1 inch (25 mm) thick.

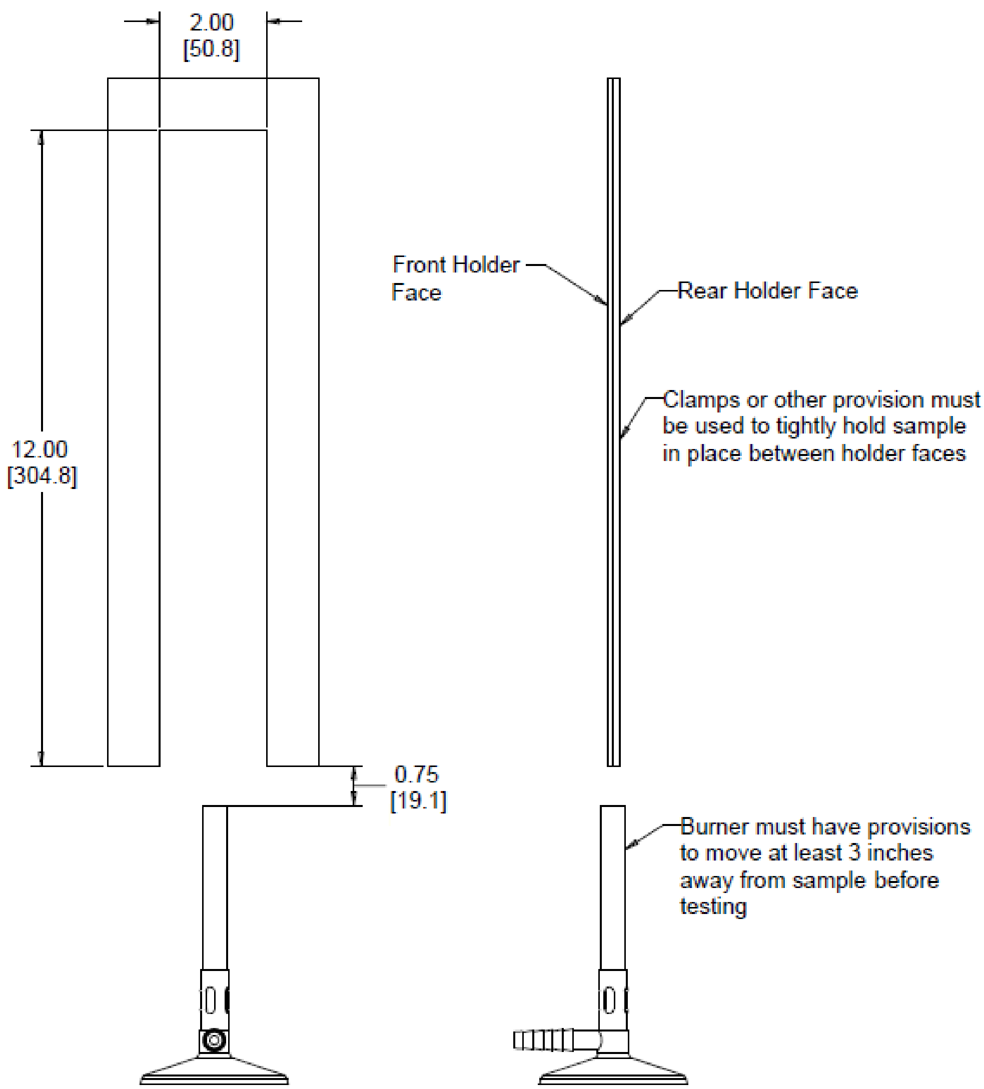


Figure A1-1. Vertical Bunsen burner test-sample holder

A1.3.3 Burner

The burner must be a Bunsen or Tirrill type. The burner must have a 0.375-inch (10 mm) inside diameter barrel. A Tirrill burner is 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. If using a Bunsen burner, there must be a means of regulating the gas flow (e.g., a needle valve) to achieve the flame height, and all aspirating holes at the bottom of the burner must be closed. Either burner should have a 0.036 + 0.0002/-0.0003-inch orifice. Refer to appendix I for more burner details.

A1.3.3.1 Burner Fuel

A diffusion flame using methane gas of 99 percent certified purity (CP) must be used (i.e., without adding air through the aspirating holes at the bottom of the burner barrel).

A1.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure A1-2. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2.5 ± 0.25 psi (17 ± 2 kPa) at the burner inlet must be installed between the gas supply and the burner. If using a Bunsen burner, a needle valve needs to be placed between the fuel pressure regulator and burner inlet to control the flame height.

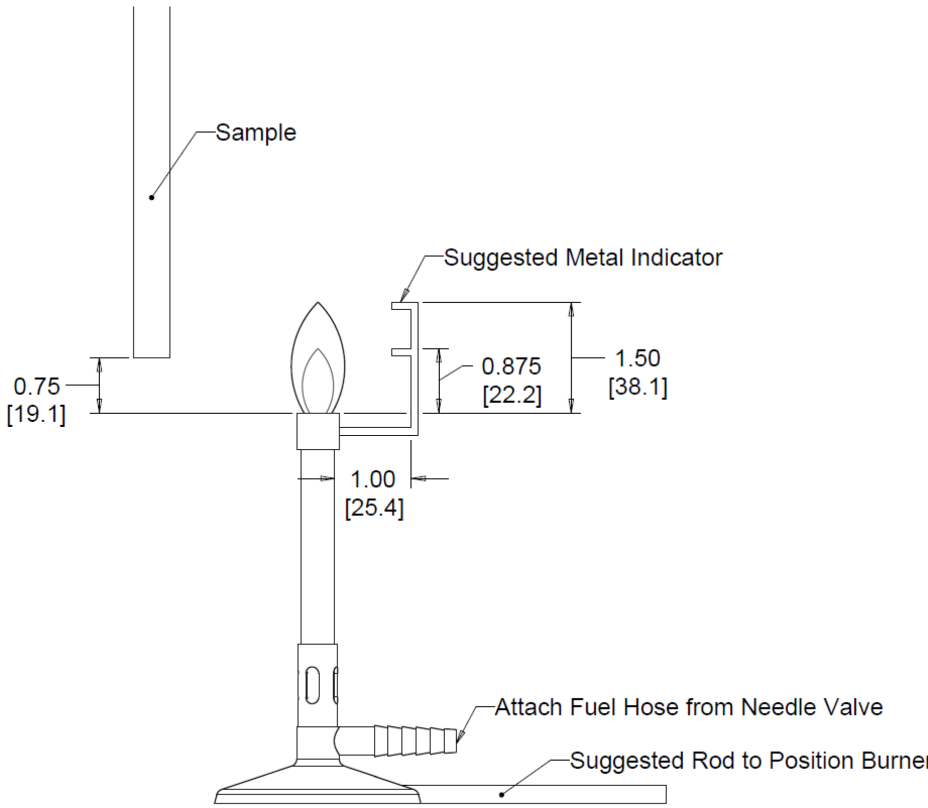


Figure A1-2. Burner plumbing and burner flame-height indicatorA1.3.3.3 flame-height indicator

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 is spaced 1 inch (25 mm) from the burner barrel, as shown in figure A1-3. Alternatively, a separate indicator that is held up next to the flame by hand to get the proper flame height may be used instead. Refer to appendix I for more details.

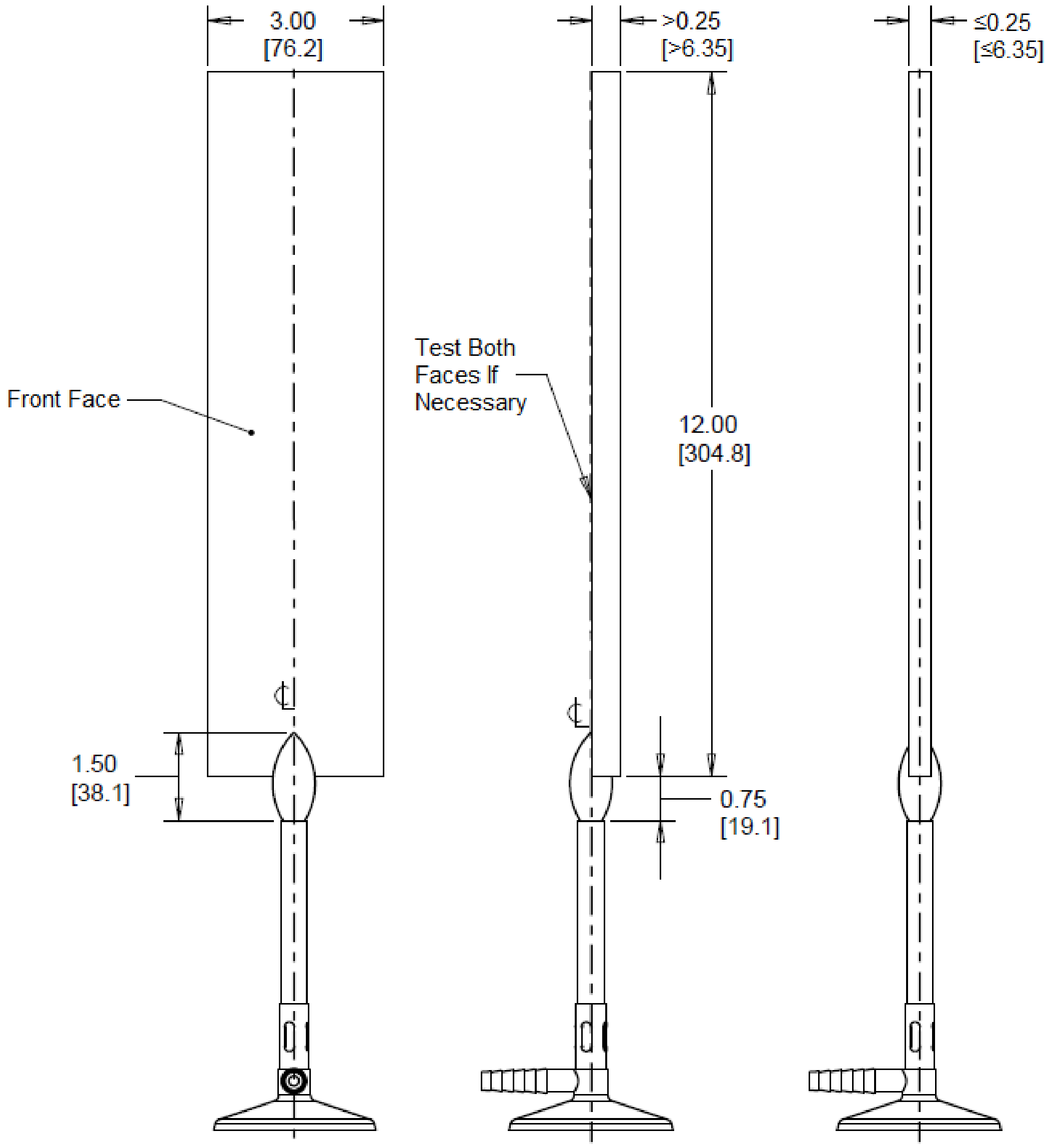


Figure A1-3. Flame position on vertical samples

NOTE: More information is available in DOT/FAA/CT-86/22, "An Investigation of the FAA Vertical Bunsen Burner Flammability Test Method."

When 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 the proper flame profile is achieved when the height of the inner cone is 0.875 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long.

NOTE: 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. However, the inner cone of the flame is 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.

A1.3.4 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame, the flame time, and the drip flame time.

A1.3.5 Ruler

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

A1.4 Test Samples

A1.4.1 Sample Selection

Samples tested must 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 sample 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 sample. Fabricated units, such as sandwich panels, must not be separated into individual component layers for testing.

A1.4.1.1 Directionality

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

A1.4.2 Sample Number

Each separate set of samples prepared for testing must consist of at least three samples.

A1.4.3 Sample Size

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

NOTE 1: If the sample length is less than the burn length requirement, then, as long as the sample does not burn its full length, it passes the burn length requirement.

NOTE 2: By regulation, there must be at least 2 inches of the sample exposed; however, the text specifies a sample cut 3 inches in width. This allows enough material to ensure that the sample 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 wider than 3 inches. This allows the operator adequate material to pull or adjust so that the sample does not buckle or fall out of the holder.

A1.4.4 Sample Thickness

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

A1.4.4.1 If the part construction is used in several thicknesses, the minimum thickness must be tested.

A1.4.4.2 Foam parts that are thicker than 0.5 inch (13 mm), such as seat cushions, must be tested in 0.5-inch (13-mm) thicknesses.

A1.4.4.3 Parts that are smaller than the size of a sample and cannot have samples 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.

NOTE: The sample thickness should 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 sample, then vertical testing may be conducted and test data recorded for further review.

A1.5 Conditioning

Samples will be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing. Remove only one sample at a time from the conditioning environment immediately before testing.

NOTE: Only one sample should 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 sample at a time only if each sample is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination, such as dirty lab tops and soot in the air, until the sample is subjected to the flame.

A1.6 Test Procedure

A1.6.1 Burner Adjustment

A1.6.1.1 Ensure that the air supply to the burner is shut off.

A1.6.1.2 Open the valve in the gas line fully and light the burner.

A1.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height, in accordance with section A1.3.3.3.

A1.6.2 Test Procedure

A1.6.2.1 Place the burner at least 3 inches (76 mm) from where the sample will be located during the test.

A1.6.2.2 Insert the sample with its lower edge 0.75 inch (19 mm) above the level of the top of the burner.

A1.6.2.3 Close the cabinet door or enclosure, and keep it closed during the test. It is important to note that the test must be watched carefully while it is being conducted. This applies to all samples.

A1.6.2.4 Start the timer immediately on positioning the burner. For sample thicknesses greater than 0.25 inch (6.35 mm), position the burner so that the flame impinges on the midpoint of the lower edge of the front face of the test sample. Test the front and back surfaces separately unless the surfaces are of the same materials and construction. For sample thicknesses of 0.25 inch (6.35 mm) or less, place the burner centered with the bottom surface of the sample. In this configuration, a single test can substantiate both surfaces of a test sample. (see figure A1-3).

A1.6.2.5 Apply the flame for 12 seconds (or 60 seconds), and then withdraw it by moving the burner at least 3 inches (76 mm) from the sample or by turning the gas off. Watch the test carefully while it is being conducted to more easily determine the extent of damage on the sample due to combustion.

NOTE: Rerun the test if the burner extinguishes during the ignition time for any reason. From experience, it has been found that this is necessary 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 3 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 sample cooling and compromising test results. The opposite end of the same sample can be used for the retest if the burn length for the aborted test is 3 inches (76 mm) or less. If the burn length for the aborted test is greater than 3 inches (76 mm), a new sample must be used.

NOTE: If testing a sample that needs both faces tested, the opposite face on the opposite end of the same sample can be used for a second test if the burn length on the first test is 3 inches (76 mm) or less. If the burn length for the first test is greater than 3 inches (76 mm), a new sample must be used.

A1.6.2.6 If flaming material falls from the test sample, determine the drip flame time for the sample.

A1.6.2.7 Determine the flame time for the sample.

A1.6.2.8 After all flaming ceases, open the cabinet or enclosure door slowly to clear the fumes and smoke. The exhaust fan should be turned on to facilitate clearing smoke and fumes.

NOTE: The operator should refer to the facility's safety manual for further information on dealing with smoke and flammability byproducts.

A1.6.2.9 Remove the sample 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 sample material), may be used to remove soot and stain particles from the tested samples.

NOTE: Because 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.

Whereas burn lengths of materials used in modern aircraft interiors generally fall well below the 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: polymeric materials (such as panels, partitions, or transparencies, 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. To fix the boundary where the flame front was impinging on the sample surface and damaging the sample due to that area's combustion (i.e., the area below which combustion of the sample occurred and above which it did not), it is necessary to observe the sample continuously during the test. Flame impingement on the sample may lead to outgassing due to thermal decomposition. As these gases burn, radiating heat may cause discoloration, sooting, staining, and melting 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 sample from the test cabinet, allow the sample to cool and then measure the burn length. The burn length is the distance from the end of the sample that was exposed to the flame to the top of the lengthwise tear made through the center of the charred area. Fold the sample lengthwise and crease it by hand along a line through the highest peak of the charred area. Insert the hook into the sample (or insert it into a hole, 0.25 inch (6 mm) or less in diameter) at one side of the charred area 0.25 inch (6 mm) in from the lower end. Attach a weight to the hook of sufficient size (the weight and hook together should equal the total tearing load required, as shown in table A1-1).

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

Table A1-1. 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	
Ounce/yard^2	g/m^2	Pounds	kg
2.0 to 6.0	68 to 203	0.25	0.1
More than 6.0 to 15.0	Over 203 to 508	0.5	0.2
More than 15.0 to 23.0	Over 508 to 780	0.75	0.3
More than 23.0	Over 780	1.0	0.45

c. Carpeting. Tear the sample with your hands. Use only enough force to tear the charred material. Stop when the fabric does not give way freely. The backing material may not be able to be torn while the front fabric still can.

d. Polyurethane Foams. Polyurethane foams are cellular in nature and, therefore, have low thermal conductivity. Because 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.

A1.6.2.10 Remove any material from the bottom of the cabinet or enclosure that fell from the sample. If necessary, clean the test cabinet or enclosure window/backface mirror prior to testing the next sample.

A1.7 Report

A1.7.1 Material Identification

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

A1.7.2 Test Results

A1.7.2.1 Ignition Time

Report whether the ignition time was 12 or 60 seconds.

A1.7.2.2 Flame Time

Report the flame time for each sample tested. Determine and record the average value for flame time (see section A1.2.2).

A1.7.2.3 Drip Flame Time

Report the drip flame time for each sample tested. Determine and record the average value for the drip flame time (see section A1.2.3). For samples that have no drips, record “0” for the drip flame time and also record “No Drips.”

A1.7.2.4 Burn Length

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

A1.8 Requirements

A1.8.3 Burn Length

The burn length for at least 80 percent of the samples tested cannot exceed 8 inches (203 mm) for the 12-second vertical test or 6 inches for the 60-second vertical test. If the minimum three samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experience an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Chapter A2
Radiant Heat Test for Evacuation Slides, Ramps, and Rafts

A2.1 Scope

A2.1.1 Test Method

This test method evaluates the ability of an evacuation slide material to resist heat and maintain pressure when subjected to a radiant heat source that simulates a large jet fuel fire. This test method also may be used to show compliance with Technical Standard Order (TSO) C69A.

A2.2 Definitions

A2.2.1 Time to Failure

The time to failure is the time between first application of heat to the sample and the first decrease in pressure below the maximum pressure attained in the test cylinder during the test.

A2.2.2 Test Sample

A test sample must replicate the material used in the pressurized portion of an evacuation slide vessel.

A2.3 Test Apparatus

A2.3.1 Pressure Cylinder Sample Holder

The pressure cylinder consists of a 12-inch long (314 mm) aluminum cylinder with a 7-inch (178 mm) outside diameter (OD) and a 6.5-inch (165 mm) inside diameter (ID), and is used to hold the test sample in place and under pressure in front of the radiant heat source. Figure A2-1 shows an overview diagram of the test apparatus. Refer to appendix J for more details on the pressure cylinder and supporting parts.

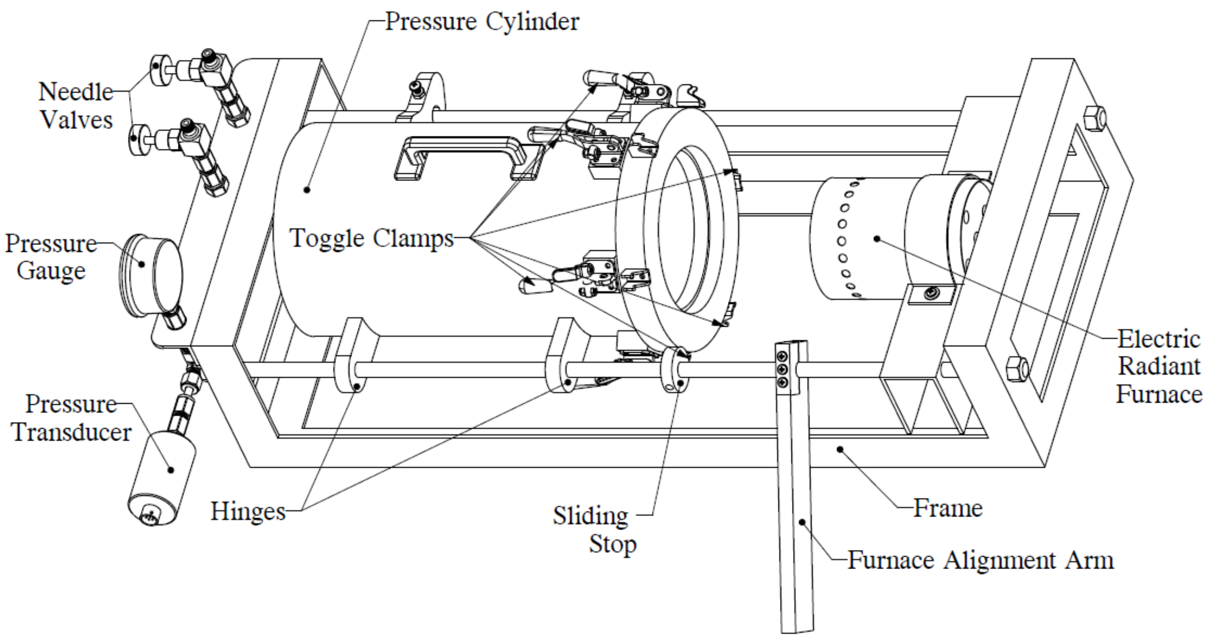


Figure A2-1. Overview of evacuation slide material test apparatus

A2.3.2 Electric Furnace

An electric radiant furnace with a 3-inch (76-mm) diameter opening, as shown in figure A2-1, must be used to supply a constant irradiance on the sample surface. The diameter of the spiral element is nominally 3 inches. It is an 875-watt, 120-volt alternating current (AC) element with an internal resistance of approximately 17 ohms. It is shown to the right of the pressure cylinder in figure A2-1. Refer to appendix J for more details on the electric furnace.

A2.3.3 Furnace Voltage Control

A variable voltage control unit, 115-volt, 600-watt minimum, will be connected to the electric furnace power supply to adequately control the heat flux from the furnace. The furnace control system will be capable of maintaining the irradiance level under steady-state conditions for a minimum of 20 minutes.

A2.3.4 Voltmeter

The voltmeter is used to measure the input AC voltage going to the furnace and must have a range capable of measuring the maximum AC voltage produced by the input circuitry (typically 0–120 volts or 0–240 volts).

A2.3.5 Ammeter

The ammeter is used to measure the input AC current going to the furnace, and must have a minimum range of 0–7.5 amperes.

A2.3.6 Apparatus Framework

A2.3.6.1 Pressure Supply and Equipment

Compressed air is supplied to the pressure cylinder through a needle valve attached to the end of the framework. A tee-manifold on the outlet side of the valve provides for a 0–5 psig pressure gauge, a transducer, a flexible tube to supply air to the rear plate of the pressure cylinder, and a bleed valve, as shown in figure A2-2.

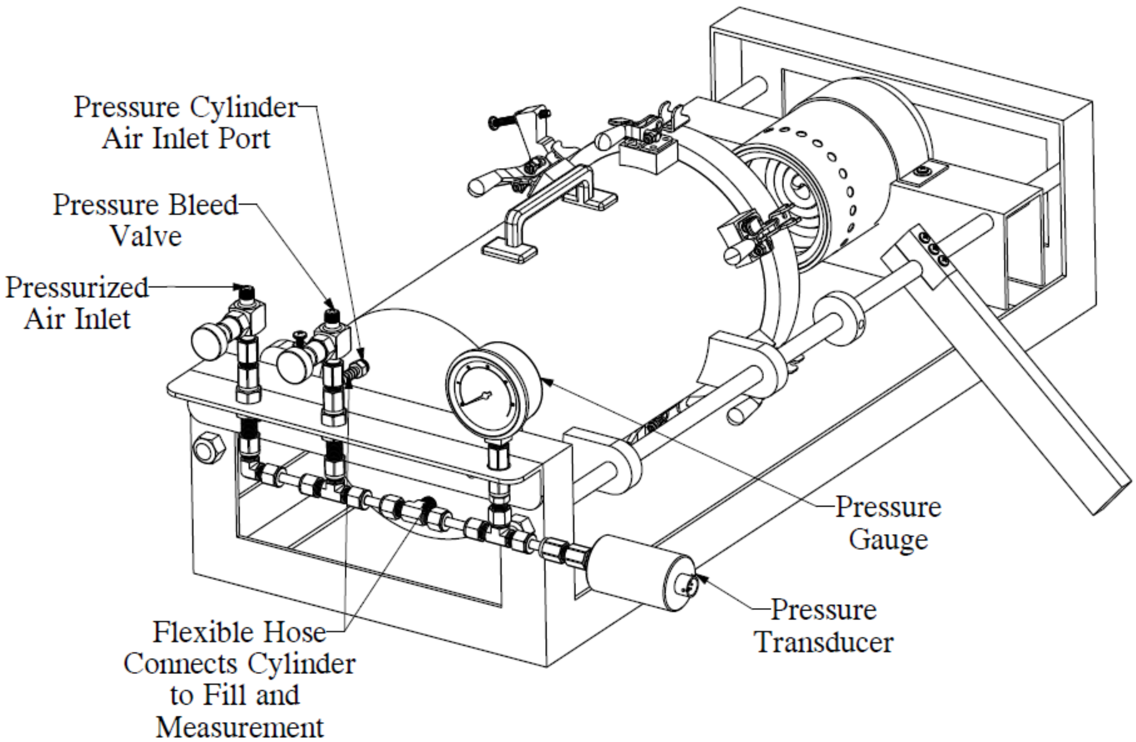


Figure A2-2. Evacuation slide test apparatus in test position

A2.3.7 Instrumentation

A2.3.7.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the power input of the furnace and pressure transducer. If a voltmeter is used, it requires a resolution of 0.01 mV and an accuracy of 0.3 percent.

A2.3.7.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame and the test-sample ignition and extinguishment times.

A2.4 Apparatus Configuration

A2.4.1 Power Measurement Hardware

The source voltage (typically from a wall outlet) must first go to the voltage regulator to control the voltage input to the furnace. The output of the voltage regulator connects to the ammeter, which then connects to the furnace. The voltmeter is connected between the positive and negative leads going to the furnace. The voltage and current readings must be recorded during testing by a computerized data-acquisition system or other calibrated recording device. The data-acquisition system is connected to the voltmeter and ammeter to record the data and calculate the power input. Figure A2-3 shows a schematic of this configuration.

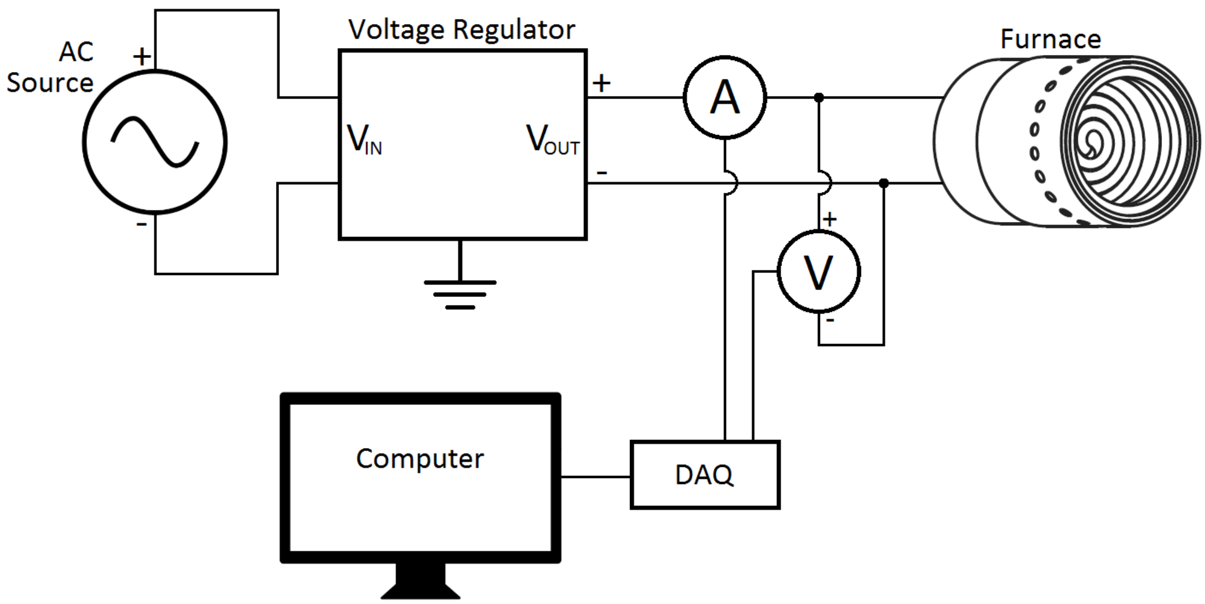


Figure A2-3. Schematic of power measurement hardware

A2.5 Test Samples

A2.5.1 Sample Selection

Samples tested must be either cut from a fabricated slide as installed in the aircraft or cut from a section simulating a fabricated slide (e.g., cut from a flat sheet of material that simulates the fabricated slide). The sample may be cut from any location in the fabricated slide; however, the surface exposed to the burner must not consist of the finished or protected edge of the sample.

A2.5.1.1 Sample Directionality

For slides that may have different flammability characteristics in different directions (e.g., textiles), separate sets of samples cut from each direction showing the greatest difference (e.g., warp and fill) must also be tested.

A2.5.1.2 Sample Representation

If the evacuation slide (pressure holding material) has any exposed surfaces that are marked, overlay material, seams, or altered in any other manner that affects radiant heat resistance, each different surface must be tested as a separate sample set.

A2.5.2 Sample Number

Each separate set of samples prepared for testing must consist of at least three test samples.

A2.5.3 Sample Size

The test sample must be 7 inches (178 mm) in diameter with eight 0.25-inch (6-mm) holes punched in the material to match the studs in the pressure cylinder.

A2.5.4 Test-Sample Operating Pressure

Nominal operating pressure is the pressure that the slide will generally achieve when deployed under normal operating conditions. Each evacuation slide material has its own nominal operating pressure for the test. The nominal test pressure is the midpoint pressure between the highest and lowest normal deployment range pressures.

A2.5.5 Test-Sample Conditioning

Condition test samples at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

A2.6 Furnace Calibration

A2.6.1 Conduct the calibration in a draft-free room or enclosed space.

A2.6.2 Level the pressure cylinder and the furnace. Make certain that the center line of the pressure cylinder will line up with the center of the furnace when positioned in front of it.

A2.6.3 Turn on the radiant heat furnace and other required instrumentation, and allow 30 to 45 minutes to stabilize the heat output and instrumentation.

A2.6.4 Adjust the transformer voltage to set the power input of the furnace at 425– 433 watts. This power input is required for the test calibration. This will produce a heat flux of 1.50 Btu/ft^2·sec at the required 2-inch distance from the furnace.

NOTE: To prolong the life of the furnace, increase the voltage slowly.

A2.6.5 Do not turn off the furnace. Use this radiant heat output for the test.

A2.7 Procedure

A2.7.1 Conduct the test in a draft-free room or enclosed space. It is recommended that tests be conducted under a hood or other means to remove potentially hazardous gases from the test area.

A2.7.2 Mount the test sample with the reflective surface of the material facing the furnace on the open end of the cylinder. A neoprene gasket or comparable gaskets, such as silicone, must be positioned on each side of the test sample. Place the aluminum ring on the studs and tighten the nuts to 30 inch-pounds so that an airtight seal is achieved.

NOTE: It is acceptable to use Toggle clamps instead of nuts and bolts (see figure A2-1) as a method to secure the test sample in place between the aluminum ring holder and the pressure cylinder.

A2.7.3 Pressurize the cylinder to the correct operating pressure for the test-sample material and check for leakage. The nuts must be torqued before and after the cylinder is pressurized to prevent air leakage from the cylinder. Ensure that the test sample holds the pressure for at least 3 minutes before testing. During this time, place a sheet of insulation board in front of the sample, without making contact with the sample, to block any radiant heat from the furnace before the test starts (see figure A2-4).

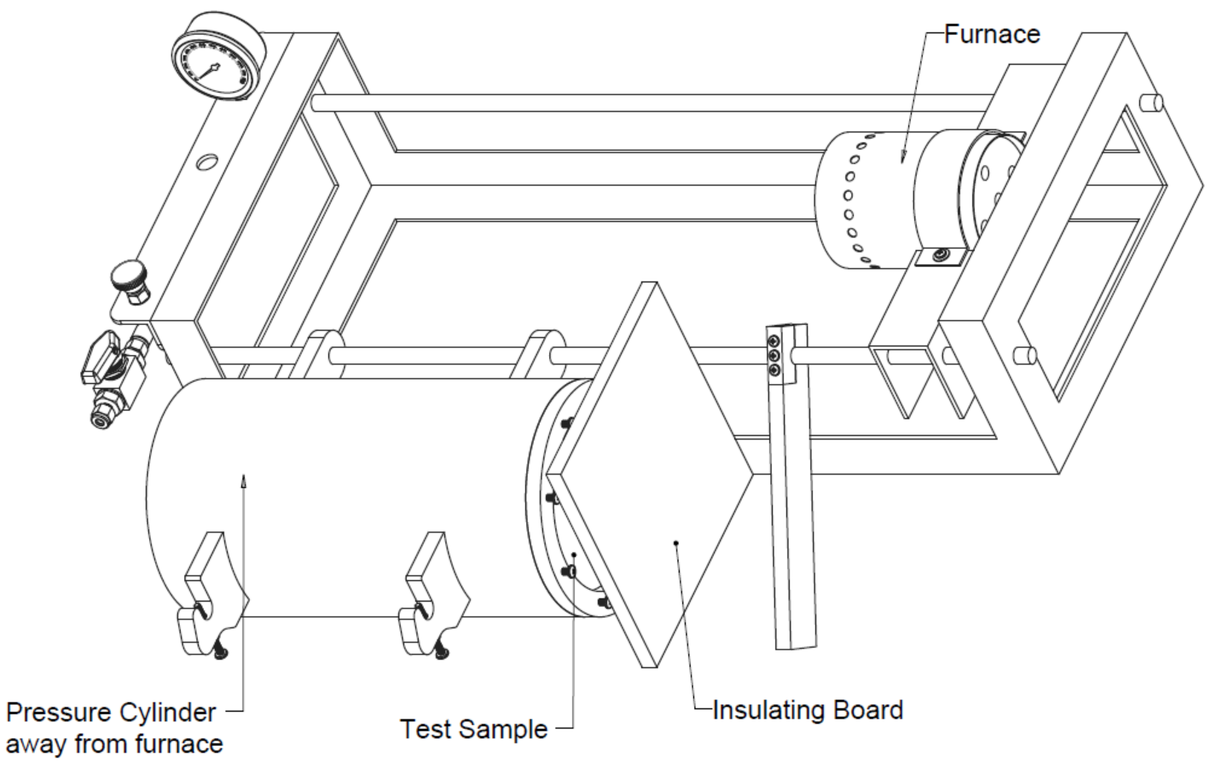


Figure A2-4. Insulating board placed in front of sample during 3-minute waiting period

A2.7.4 Using the sample distance measuring tool, check the distance from the center of the expanded surface of the test sample to the furnace. Ensure that this distance will be 2 inches once the pressure cylinder with test sample is rotated into test position (see figure A2-5).

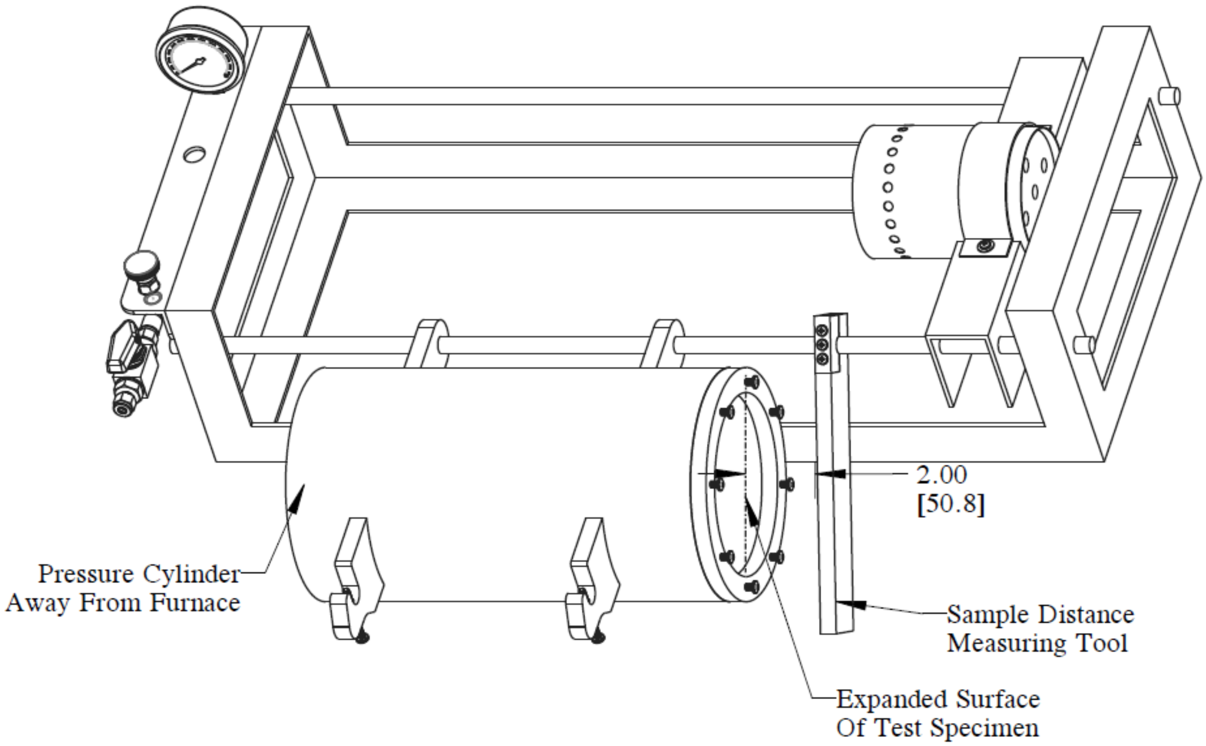


Figure A2-5. Sample to furnace distance measurement

A2.7.5 Check and make sure the power input is 425–433 watts in the monitor.

A2.7.6 Rotate the pressurized cylinder with the test sample in front of the radiant heat furnace. Simultaneously start the timer.

A2.7.7 Monitor the pressurized cylinder from the time the test sample is placed in front of the furnace until the first observed pressure loss.

A2.7.8 Record time to failure in seconds.

A2.7.9 The duration of the test is 180 seconds.

A2.8 Report

A2.8.1 Report material description and full identification of the sample. This may include type of fabric and coating, manufacturer, manufacturer style number, weight, thickness, color, and any alterations, if applicable.

A2.8.2 Report the starting pressure for each of the three samples.

A2.8.3 Report any observations of the material's behavior during the test and times of the occurrence.

A2.8.4 Report the time to failure for each of the test samples.

A2.9 Requirement

A2.9.1. A minimum of three samples must be tested. At least 80 percent of the test samples must maintain the correct pressure for a minimum of 180 seconds. If the minimum three samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experience an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Chapter A3
Oil Burner Flammability Test for Seat Cushions

A3.1 Scope

A3.1.1 Applicability

This test method evaluates the burn resistance and weight-loss characteristics of aircraft seat cushions when exposed to a high-intensity open flame to show compliance to the requirements of 14 CFR 25.853.

A3.2 Definitions

A3.2.1 Vertical Assembly

The vertical assembly is the back cushion located in the vertical orientation. The vertical assembly may be representative of the production seat back, seat bottom, or both if the production articles have the same construction.

A3.2.2 Horizontal Assembly

The horizontal assembly is the bottom cushion in the horizontal orientation. The horizontal assembly may be representative of the production seat back, seat bottom, or both if the production articles have the same construction.

A3.2.3 Seat Test Sample

A seat test sample consists of one vertical assembly and one horizontal assembly. Both assemblies represent the same production cushion constructions; that is, both vertical and horizontal assemblies in the seat test sample have identical construction and materials proportioned to correspond to either the actual seat bottom or back cushion, but not both. For various reasons, seat bottom and back cushions on actual aircraft seats are typically slightly different.

NOTE: Foam headrest and footrest cushions should be treated the same as vertical and horizontal assemblies and tested as complete samples if their construction is different from the seat bottom (horizontal) and/or seat back (vertical) cushions. In some cases, it may be reasonable to include the headrest as part of the seat back cushion. In such a case, the cushions should be constructed as for foam combinations.

A3.2.4 Seat Test-Sample Set

A seat test-sample set consists of three or more replicate seat test samples.

A3.2.5 Burn Lengths

The four principal burn lengths are measured along the top side of the horizontal assembly, bottom side of the horizontal assembly, front side of the vertical assembly, and the back side of the vertical assembly. The four burn lengths are defined as the distance measured in inches from the inside edge of the test-sample mounting frame (nearest the burner cone) to the farthest point where damage to the seat test sample occurred due to that area's combustion, including partial or complete consumption, charring, or embrittlement. However, this does not include areas that are merely sooted, stained, warped, or discolored.

A3.2.6 Percent Weight Loss

The percentage weight loss for a seat test sample is the pretest weight of the seat test sample less the posttest weight of the seat test sample expressed as the percentage of the pretest weight. All droppings falling from the seat test sample and test-sample mounting frame are to be discarded prior to determining the post-test weight.

A3.3 Apparatus

A3.3.1 Test-Sample Apparatus

The test-sample apparatus includes the seat test-sample mounting frame and drip pan. The test-sample apparatus must allow movement of the test sample so it can be positioned in front of the burner at the proper distance. It is recommended that the apparatus allow for a minimum 36 inches of distance between the burner cone and sample during burner warmup to prevent preheating of the sample.

A3.3.1.1 Test-sample Mounting Frame

The mounting frame for the seat test sample will be fabricated of 1- by 1- by 0.125-inch (25- by 25- by 3-mm) stainless-steel angle and 1- by 0.125-inch (25- by 3-mm) stainless steel flat stock as shown in figure A3-1. The dimensions listed for the test-sample mounting frame are all inside measurements. The frame's upright section used for mounting the vertical assembly must be 33 ± 0.125 inches high and 18.125 ± 0.125 inches wide. The frame's bottom section used for mounting the horizontal assembly must be 18.125 ± 0.125 inches wide and 22.125 ± 0.125 inches long. The vertical and horizontal mounting surfaces should have two supporting braces made from 1- by 0.125-inch steel flat stock. The centerlines of the flat stock braces are 6 ± 0.125 inch measured from the outer edges of the steel angle on the left and right sides of the frame. Four legs fabricated of 1- by 1- by 0.125-inch steel angle and 12 ± 0.125 inches tall are located below the four corners of the horizontal assembly mounting section of the frame. All connecting joints of the stand are welded, and the flat stock components are butt welded. The test-sample mounting frame is used for mounting the seat test sample's horizontal and vertical assemblies. The position of the test-sample mounting frame relative to the burner cone during testing must be positioned as shown in figure A3-2.

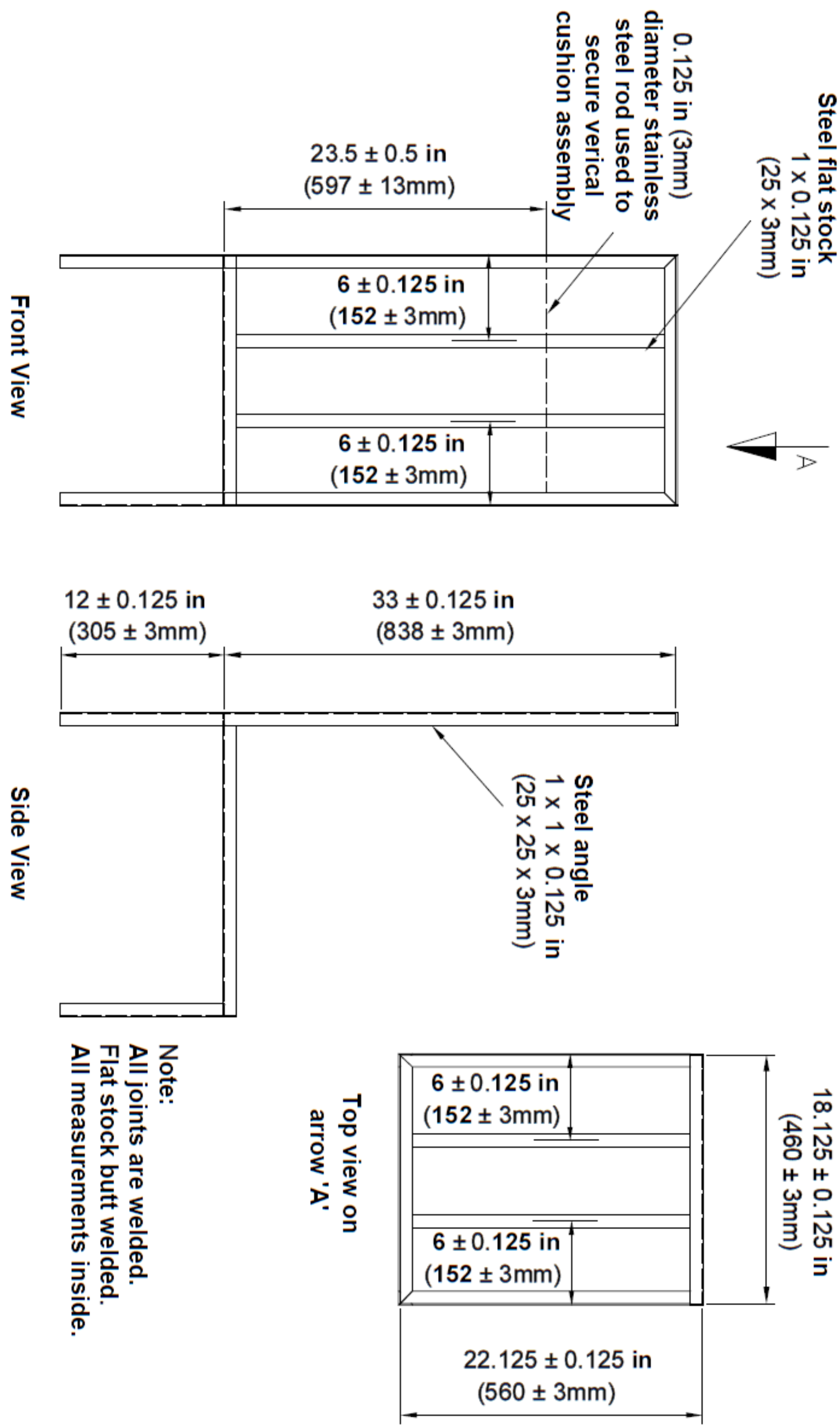


Figure A3-1. Front, side, and top views of seat test-sample mounting frame

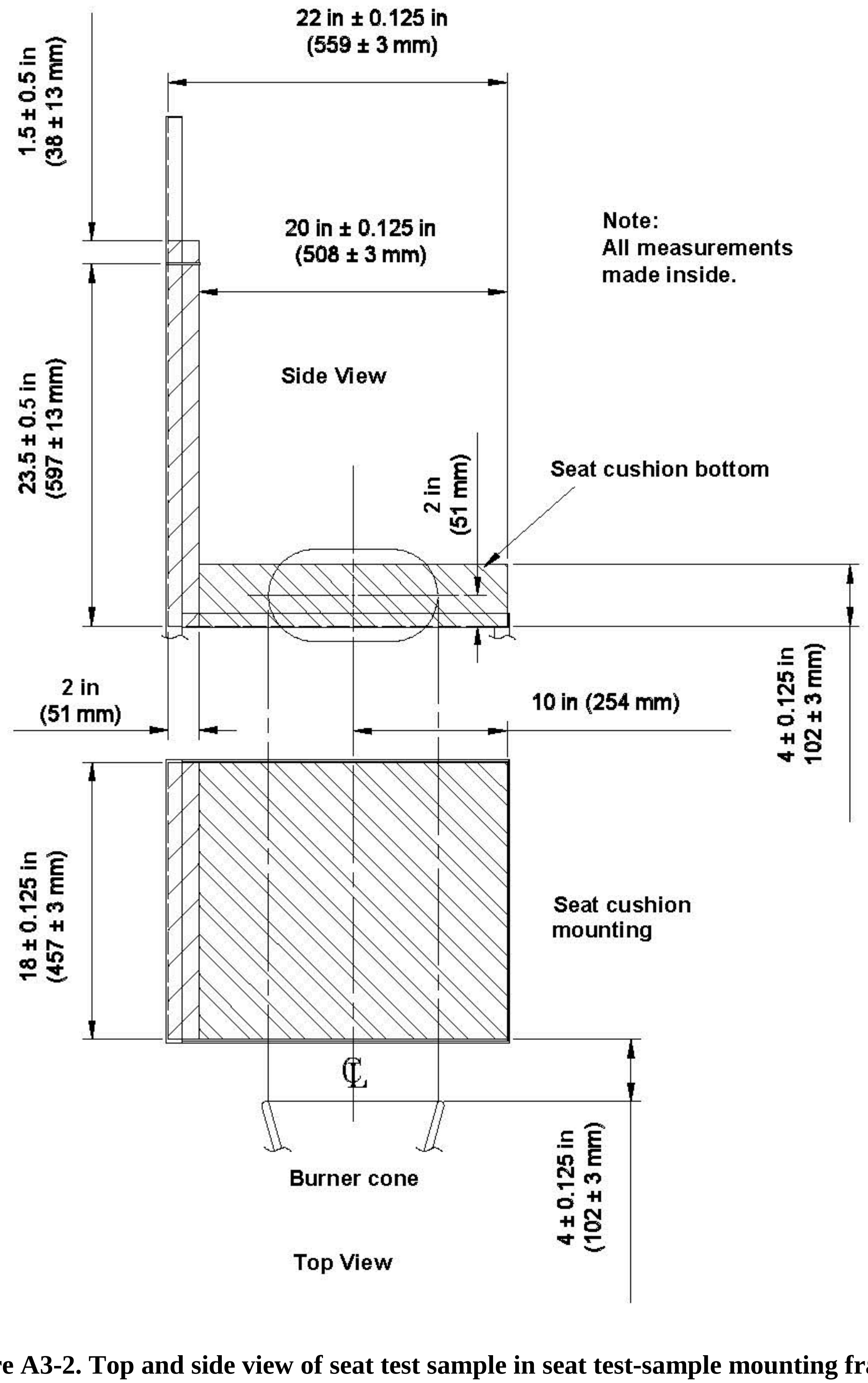


Figure A3-2. Top and side view of seat test sample in seat test-sample mounting frame

A3.3.1.1.1 Restraint Method for Fabric Dress Covered Samples

A stainless-steel rod will be used to aid in securing the vertical seat cushion to the sample frame (see figure A3-2). The rod (see figure A3-3) will be uninsulated, solid, 0.125 inch (3 mm) in diameter and be located 1.5 ± 0.5 inch (38 ± 13 mm) from the top surface of the back (vertical) cushion assembly as it sits in the sample test frame.

A3.3.1.1.2 Restraint Method for Leather Dress Covered Samples

Because of leather's tendency to shrink away from the flame during testing, both the vertical and horizontal cushion assemblies will require rod restraints. The rods must be uninsulated, solid stainless steel measuring 0.125 inch (3 mm) in diameter (see figure A3-3). Two rods must be used to restrain the back cushion assembly, and one rod must be used to restrain the bottom cushion assembly, as shown in figures A3-4 and A3-5.

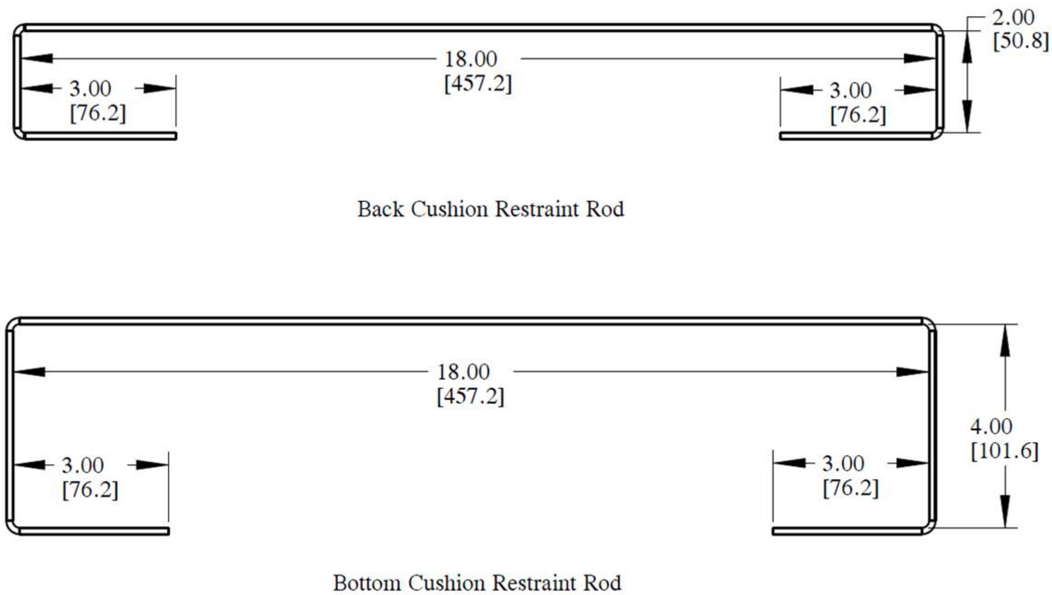


Figure A3-3. Back cushion and bottom cushion restraint rods

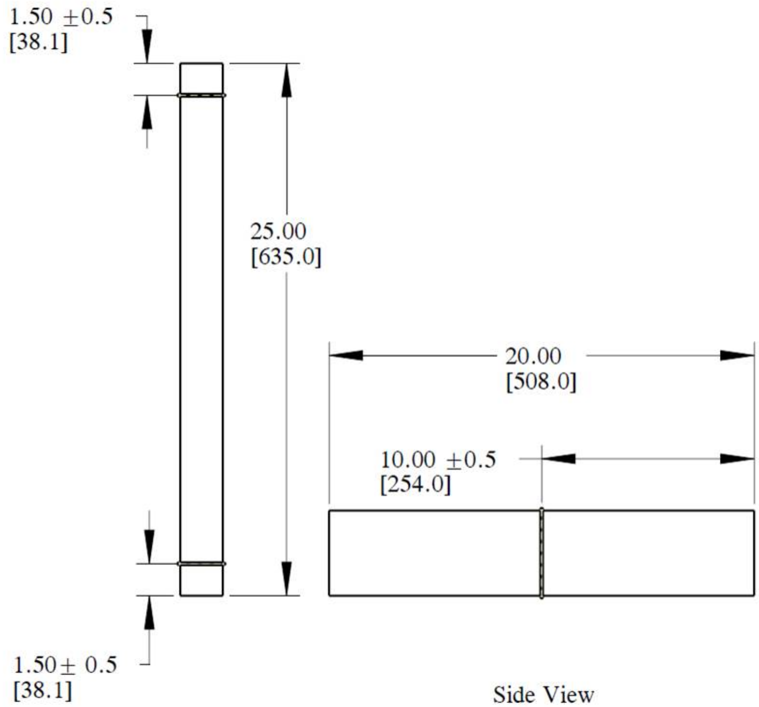


Figure A3-4. Side view of restraint rod locations for leather-covered seat samples

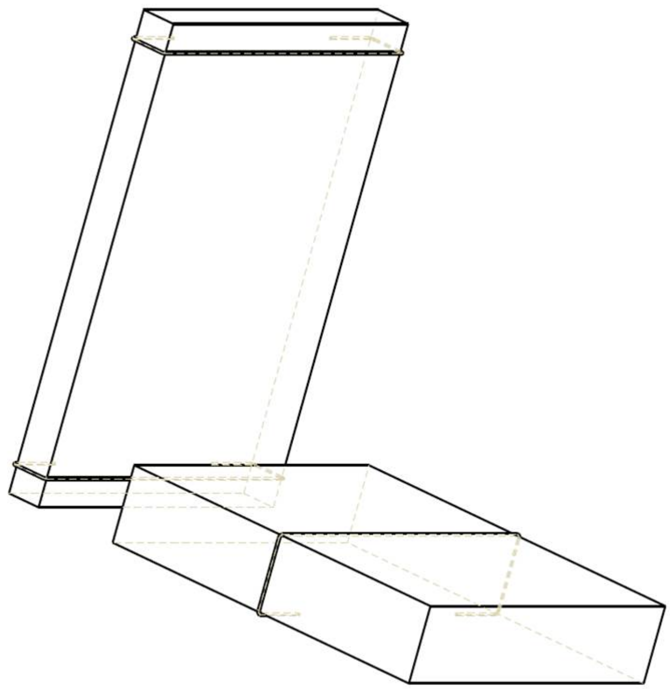


Figure A3-5. Leather-covered seat sample with rod restraints

A3.3.1.2 Drip Pan

The test-sample apparatus must include a suitable drip pan lined with aluminum foil with the dull (less reflective) side facing up. The drip pan must be located at the bottom of the test-sample mounting frame legs at a distance of 12 inches (305 mm) or greater below the portion of the test-sample mounting frame that supports the bottom (horizontal) cushion assembly.

A3.3.2 Burner

The test burner is the Sonic Fire Test Burner, described in detail in appendix K. The burner configuration for this test method is displayed in table A3-1.

Table A3-1. Burner configuration for the seat cushion flammability test

Fuel	Nozzle	2.0 gal/hr 80º Solid Spray
	Volumetric Flow Rate (gal/hr)	2.0 ± 0.1
	Pressure (psig)	110 ± 10
Air	Diffusion Method	Stator and Turbulator
	Pressure (psig)	45 ± 1
	Mass Flow Rate (SCFM)	54.2
	Burner Orientation	Horizontal

A3.3.2.1 Inlet Condition Measuring

To obtain an accurate measurement of the conditions entering the burner, the fuel pressure and temperature, and air pressure and temperature measurements must be made nearest to the burner inlet (see figure A3-6). To minimize air-stream disruptions, the intake air temperature must be measured prior to the sonic nozzle.

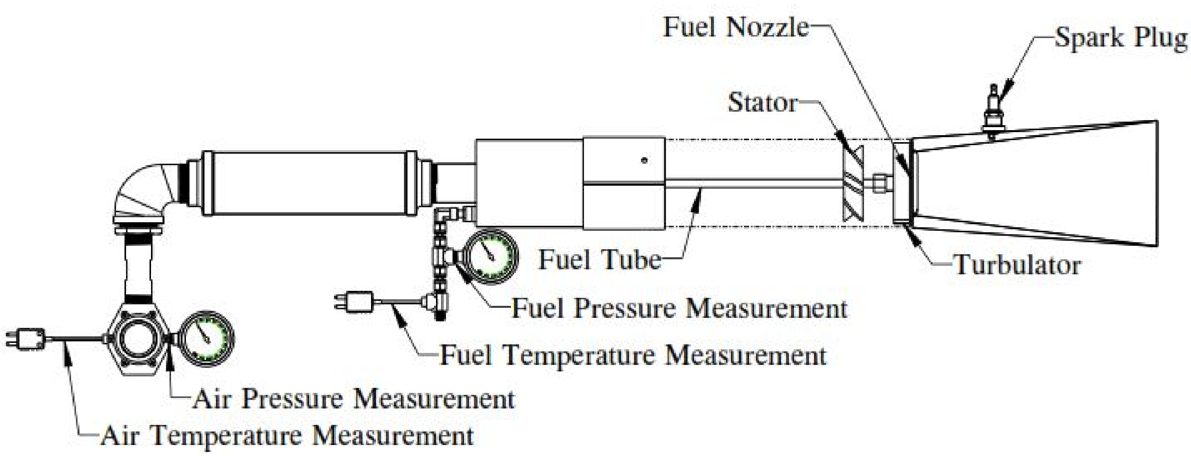


Figure A3-6. Inlet condition measurement location (side view)

A3.3.2.2 Fuel Nozzle

A screw-in style fuel nozzle is required to maintain a fuel pressure that will yield a 2 ± 0.1 gal/hr (7.57 L/hr ± 0.38 L/hr) fuel flow. A nozzle with an 80 degree solid spray angle nominally rated at 2.0 gal/hr (7.57 L/hr) at 100 lb/in^2 (0.69 MPa) has been found to deliver the appropriate flow rate and produce the proper flame pattern. Actual flow rate measurements may deviate from the advertised flow rate. The actual flow rate must be measured manually using a flexible tube, graduated cylinder, and timing device, as described in section A3.5.4.5. The fuel pressure must then be adjusted accordingly to produce the required fuel flow of 2 ± 0.1 gal/hr (7.57 L/hr ± 0.38 L/hr). For more details, refer to appendix K, section K.3.4.4, Fuel Nozzle.

A3.3.2.3 Fuel Pressure Regulation

The fuel must be properly pressurized to deliver the proper fuel flow. Ideally, this pressure must be in the range of 100 to 120 lb/in^2 (0.69 to 0.83 MPa). For details on fuel pressurization and regulation, refer to appendix K, section K.3.4, Fuel System.

A3.3.2.4 Fuel Type

A kerosene-type fuel is used in the burner equipment. Jet A and JP-8 (military equivalent to Jet A) fuel is recommended; however, other fuels are permissible if the flame temperature can be maintained according to section A3.6.1.3. For more details, refer to appendix K, section K.3.4.6, Fuel.

A3.3.2.5 Burner Cone

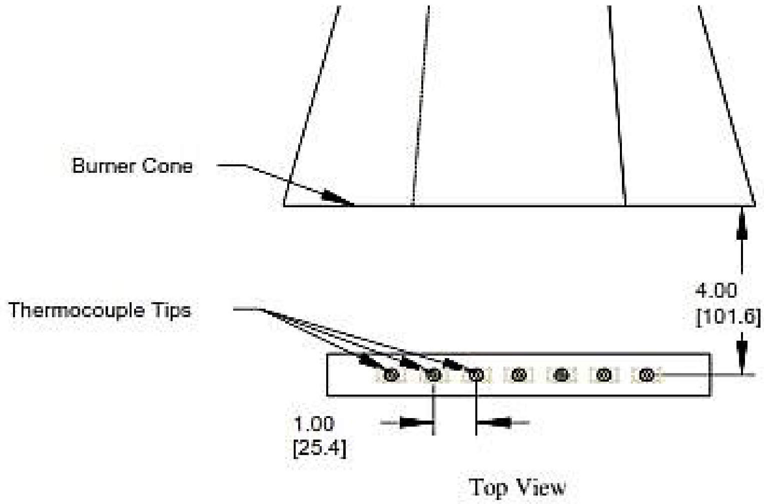
A 12 ± 0.125-inch (305 ± 3-mm) burner extension cone is fitted to the end of the burner draft tube. The opening must be 6 ± 0.125 inches (152 ± 3 mm) high and 11 ± 0.125 inches (280 ± 3 mm) wide. For more details, refer to appendix K, section K.3.7, Burner Cone.

A3.3.2.6 Spark Plug

An automotive-style spark plug is fitted into a threaded boss, which is welded to the burner extension cone. The threaded boss is centered on the upper surface of the burner cone, at a distance of 6 ± 0.125 inches (152 ± 3 mm) from the intake end of the burner cone. For more details, refer to appendix K, section K.3.5, Ignition System.

A3.3.3 Burner Flame Consistency Validation Thermocouples

Seven thermocouples must be used to check the flame temperature of the burner. The thermocouples must be 0.125-inch (3.2-mm) diameter, insulation packed, 310 stainless-steel sheathed, type K (Chromel-Alumel), grounded junction with a nominal 24 American Wire Gauge (AWG) size conductor. Thermocouples purchased with a certificate of calibration may provide more accurate readings but are not required. The seven thermocouples must be attached to a steel mounting plate to form a thermocouple rake for placement in front of the burner cone during the burner-flame consistency-validation procedure (see figure A3-7). It is recommended the thermocouple mounting plate be a minimum of 4 inches (102 mm) away from the tips of the thermocouples.



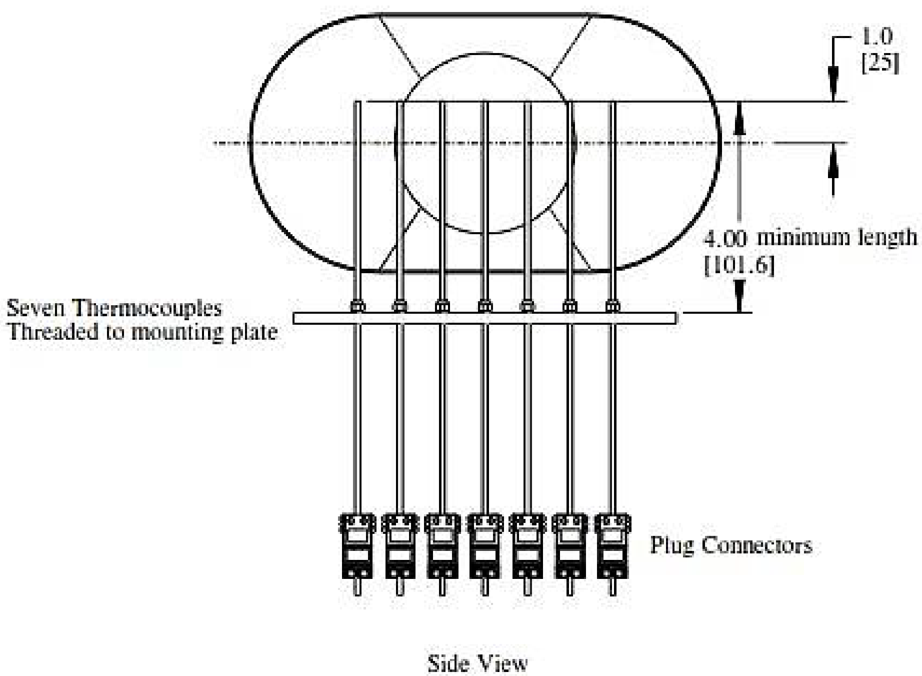


Figure A3-7. Top and side view of thermocouple rake bracket

A3.3.4 Instrumentation and Supporting Equipment

A3.3.4.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the outputs of the thermocouples.

A3.3.4.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame and the test-sample extinguishment times.

A3.3.4.3 Test Chamber Anemometer

A handheld vane- or hotwire-type air velocity sensing unit capable of measuring accurately in the 0–100 ft/min range must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating. Airflow measurements should be taken at the beginning of the day prior to operating the test burner. A suitable hotwire anemometer, which may be mounted to the sample test frame, is manufactured by Dwyer Instruments, model number 641-6-LED. A suitable handheld hotwire anemometer is manufactured by TSI, model number 9515. Vane-type anemometers typically do not function properly with airflow rates less than 50 ft/min.

A3.3.4.4 Digital Weight Scale

A suitable weight scale must be used to determine the initial and final weights of the test sample. The scale must have a resolution of 0.02 pounds (0.01 kg) and an accuracy of ± 0.02 pounds (± 0.01 kg).

A3.3.4.5 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. Although not required, the recommended minimum of the test-chamber floor area is 15 feet by 15 feet (4.57 m by 4.57 m) or larger.

NOTE: Smaller test cells may experience significant increases in ambient air temperature while testing. This may increase the severity of the test.

A3.3.4.6 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

A3.4 Test Samples

A3.4.1 Vertical Assembly (Back Cushion)

The constructed, finished sample assembly must be 18 + 0, -0.125 inches (457 + 0, -3 mm) by 25 + 0, -0.125 inches (635 + 0, -3 mm), by 2 + 0, -0.125 inches (51 + 0, -3 mm), not including fabric closures (e.g., hook-and-loop) and seam overlap.

A3.4.2 Horizontal Assembly (Bottom Cushion)

The constructed, finished sample assembly must be 18 + 0, -0.125 inches (457 + 0, -3 mm) by 20 + 0, -0.125 inches (508 + 0, -3 mm) by 4 + 0, -0.125 inches (102 + 0, -3 mm), not including fabric closures (e.g., hook-and-loop) and seam overlap.

A3.4.3 Seat Test-sample Number

A minimum of three seat test samples of the same construction and configuration must be prepared for testing.

A3.4.4 Seat Test-sample Fabrication

Each cushion assembly tested must be fabricated using the principal components (i.e., foam core, flotation material, fire-blocking material, if used, and dress covering) and assembly processes (representative seams and closures) intended for use in the production articles. If a different material combination is used for the production back cushion than for the production bottom cushion, both material combinations must be tested as a complete seat test sample. Each seat test sample will consist of a vertical cushion assembly and a horizontal cushion assembly (see figure A3-8).

NOTE: If several seat models use similar foam combinations, it is not necessary to test each combination if it is possible to bracket the various combinations. For example, if foam "A" makes up 80 percent and foam "B" makes up 20 percent of the foam volume in one seat model, and in another similar seat model foam "A" makes up 20 percent and foam "B" makes up 80 percent of the foam volume, it is generally acceptable to approve all combinations of "A" and "B" foams between these limits if the 20/80 and 80/20 extremes are tested and pass. In addition, for foams of a given chemical composition, low-density foam can be used in lieu of foams of higher density. In this case, as in the case of foam combinations, all other elements that make up the cushion must be the same (see figure A3-8 and A3-9).

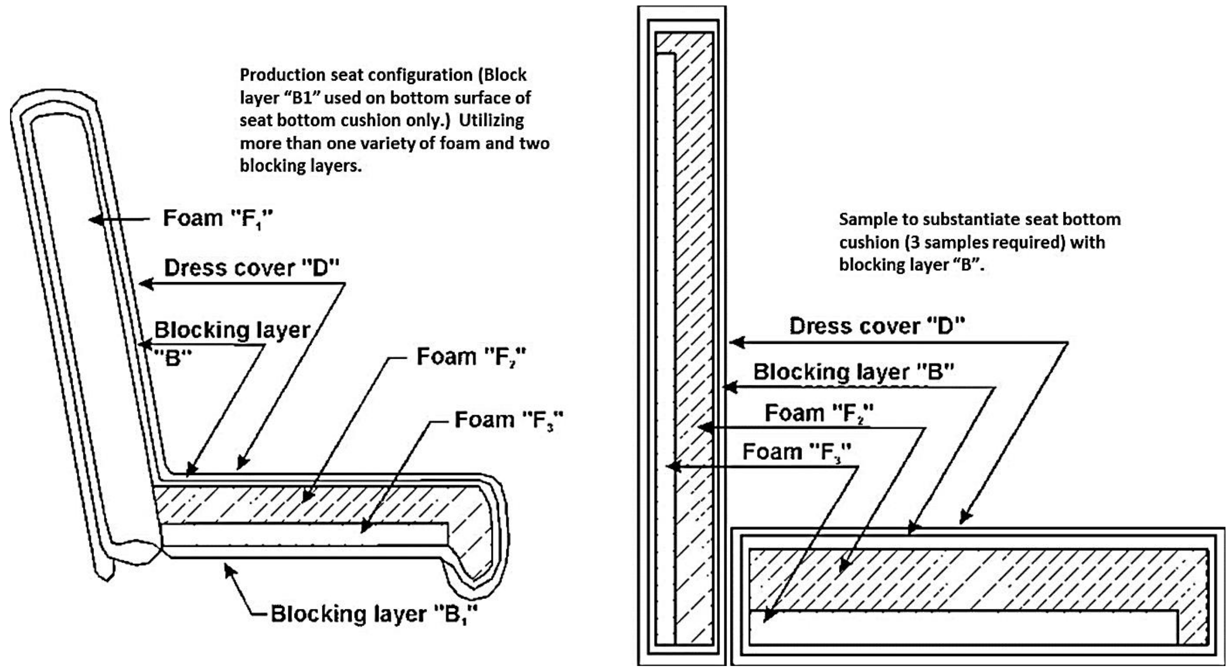


Figure A3-8. Example of production seat configuration and seat test sample to substantiate production seat bottom cushion with blocking layer "B"

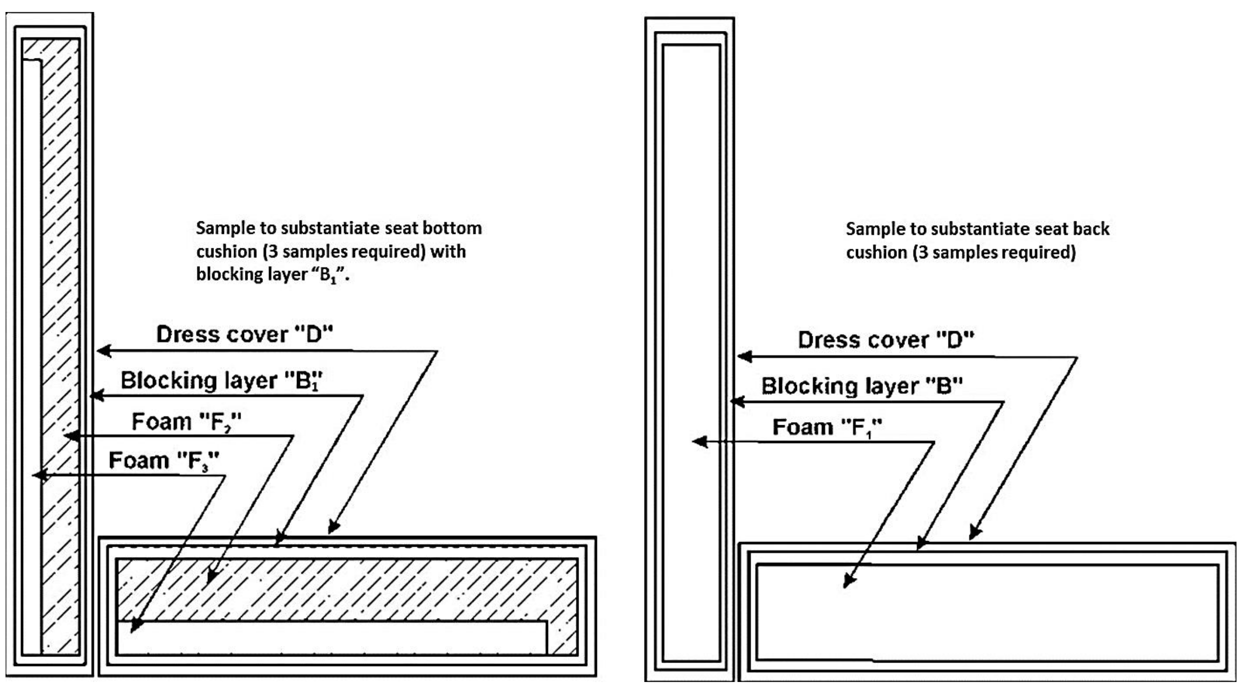


Figure A3-9. Seat test sample to substantiate production seat bottom with blocking layer "B1" and seat test sample to substantiate production seat back with blocking layer "B"

A3.4.4.1 Fire-Blocking Material

If the cushion is constructed with a fire-blocking material, the fire-blocking material must completely enclose the cushion foam core material.

A3.4.4.1.1 Cushion Assembly Fire-Blocking Fabrication

The method of fabricating blocking layer seams and closures must be the same as the production method. In fabricating a cushion assembly, the fire blocker must be configured so that any possible weak point is exposed to the burner flame. This may require configuring a cushion assembly so that the seam is exposed to the test burner, even though a seam may not be positioned as such on a production cushion.

A3.4.4.1.2 Multiple Fire-Blocking Materials

If more than one fire-blocking layer material is used on a given production cushion, each blocking layer material must be subjected to this test procedure as separate test samples. The fire-blocking material must completely encapsulate a cushion assembly so that all fire-blocking layers are subjected to the same level of test severity. Fire-blocking layers cannot be used in combination for this test (see figure A3-9).

A3.4.4.2 Foam

Seats that utilize more than one variety of foam (composition, density) must have test samples constructed that reflect the foam combination used.

A3.4.4.3 Dress Covering

If a production seat construction utilizes more than one dress covering, the test configuration may be represented as shown in figure A3-10.

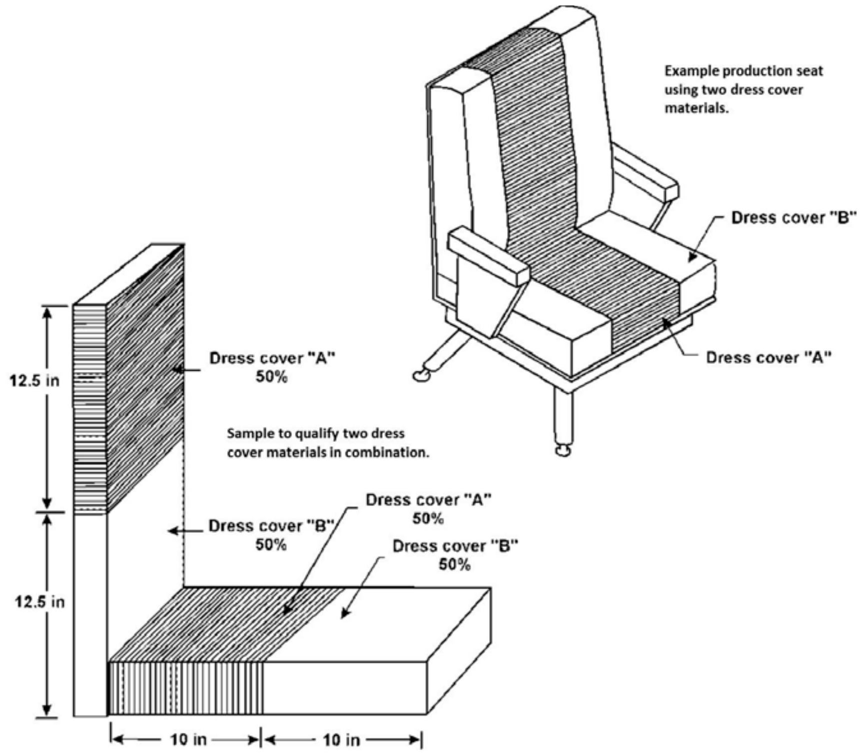


Figure A3-10. Example of production seat configuration using two dress cover materials and a seat test sample to substantiate dress cover combination

NOTE: When any seat construction tested has passed, a separate test is not required for another seat construction if the only difference from the first test is the dress covering, provided the replacement dress covering is comprised of a similar weave design and fiber type, as described in section A3.4.4.3, and the burn length of the replacement dress covering, as determined by the Bunsen burner test specified in § 25.853(b), does not exceed the burn length of the dress covering used for the test.

Seat test samples are intended to represent the principal material elements and construction methods of the production seats. Items that are decorative in nature, such as buttons, detail stitching, hand-hold straps, Velcro®-attached strips, or thin outer cover paddings like armrest covers and filler around food trays, that do not penetrate the fire-blocking layer when fastened are not required to be represented on the test sample. Dress cover details and items not associated with the cushion construction, such as metal seat pans or other metal structures, should not be included in the sample weight because they are not part of the principal seat construction. Layers of padding or filler immediately under the dress cover material are considered to be part of the dress cover material and should be included in the seat test samples.

Similar dress covering (from Advisory Circular 25.853-1, "Flammability of Aircraft Seat Cushions," sections 5d [1] and [2]) refers to dress covering materials having the same material composition, weave style, and weight. Material blends can be considered similar when the constituent materials fractions are the same, ± 6%, as the tested material. Examples of different weave styles include plain, jacquard, or velvet. With regard to *weight, lighter fabrics are generally more critical than heavier fabrics. Because of the severe shrinking and unpredictable distortion experienced by leather dress cover materials, similarity approvals for leather are not recommended.*

Certification by similarity to previously tested dress covers should be limited to instances in which the material composition is the same and the weight and weave type are essentially the same. In all cases, results of the Bunsen burner test per § 25.853(a) for the new material should be equal to or better than the tested material with respect to burn length. In addition, it may be useful to evaluate the weight-loss and burn-length results of the oil-burner test to determine if the tested material is a good basis for similarity; that is, the closer weight loss and burn length with the oil burner are to the maximum allowed, the more alike the dress covering materials should be for similarity. In general, test data and resultant experience gained from conducting tests should also be major sources of information to determine if approval by similarity is acceptable.

A3.4.5 Sample Conditioning

Samples will be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing. Remove only one sample at a time from the conditioning environment immediately before testing.

A3.5 Preparation of Apparatus

A3.5.1 Alignment

Mount a test sample on the test-sample frame. Level and center the sample frame assembly to ensure alignment with the burner cone. Move the test-sample frame into the test position in front of the burner, and check for proper alignment (i.e., distance from exit of burner cone to face of test sample, proper sample height with respect to cone centerline). The movable assembly should incorporate mechanical stops or detents to ensure that the samples can be moved into position quickly without measurement during testing.

A3.5.2 Chamber Ventilation

Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. With the test sample still in place on the test frame, measure the airflow in the test chamber using a hotwire anemometer or equivalent measuring device. The vertical air velocity can be measured 0.5 inch from the rear face of the vertical assembly, and 2 inches below the midpoint of the vertical assembly top surface. The vertical air velocity must be no greater than 100 ft/min (50.8 cm/sec). The horizontal air velocity can be measured 0.5 inch above the midpoint of the horizontal assembly top surface. The horizontal air velocity must be no greater than 50 ft/min (25.4 cm/sec).

NOTE 1: Airflow measurements do not have to be taken for each sample tested. It is recommended the airflow measurements be taken at the beginning of the day before testing and at the end of the day when testing is completed.

NOTE 2: Personnel present within the test cell may influence air velocity readings. This may be avoided by mounting the anemometer instrumentation to the sample holder during test cell air velocity measurements.

A3.5.3 Test Chamber Air Temperature

The temperature of the test chamber should be between 50°F and 100°F (10°C and 38°C) before the start of each test. The chamber air temperature should be measured 0.5 inch (13 mm) above the center of the horizontal (cushion) assembly. Remove the sample from the test frame. Do not use this sample for testing. The sample may be kept for future test chamber airflow and temperature measurements.

A3.5.4 Sonic Burner Configuration

A3.5.4.1 Fuel Nozzle Location

The tip of the fuel nozzle, or fuel exit plane, must be located 0.1875 ± 0.020 inch (4.763 ± 0.5 mm) from the exit plane of the turbulator (see figure A3-11).

A3.5.4.2 Stator Adjustment

The stator is positioned by adjusting its translational position and its axial position on the fuel rod.

A3.5.4.2.1 Stator Translational Position

The front face of the stator must be located 2.6875 ± 0.020 inches (68.263 ± 0.5 mm) from the exit plane of the turbulator (see figure A3-11). This stator translational position is also 2.5 inches (63.5 mm) from the tip of the fuel nozzle.

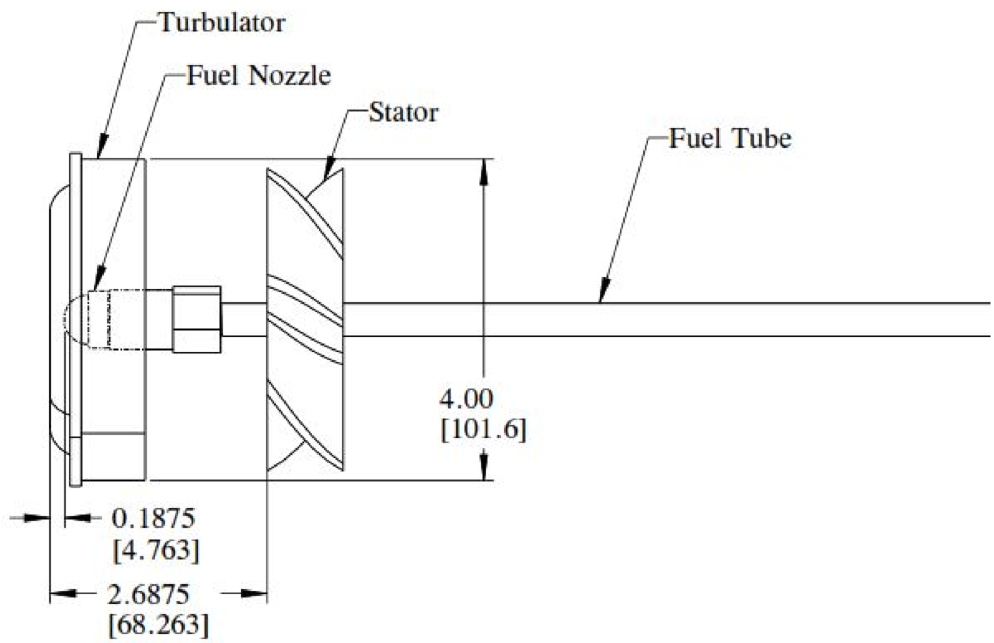


Figure A3-11. Fuel nozzle and stator locations

A3.5.4.2.2 Stator Axial Position

The line running through the set screw and geometric center of the stator will be used as a reference for properly orienting the rotational position of the stator. The stator must be positioned so the reference line angle is 0 degrees (12 o'clock) from the zero position when looking into the burner draft tube (see figure A3-12).

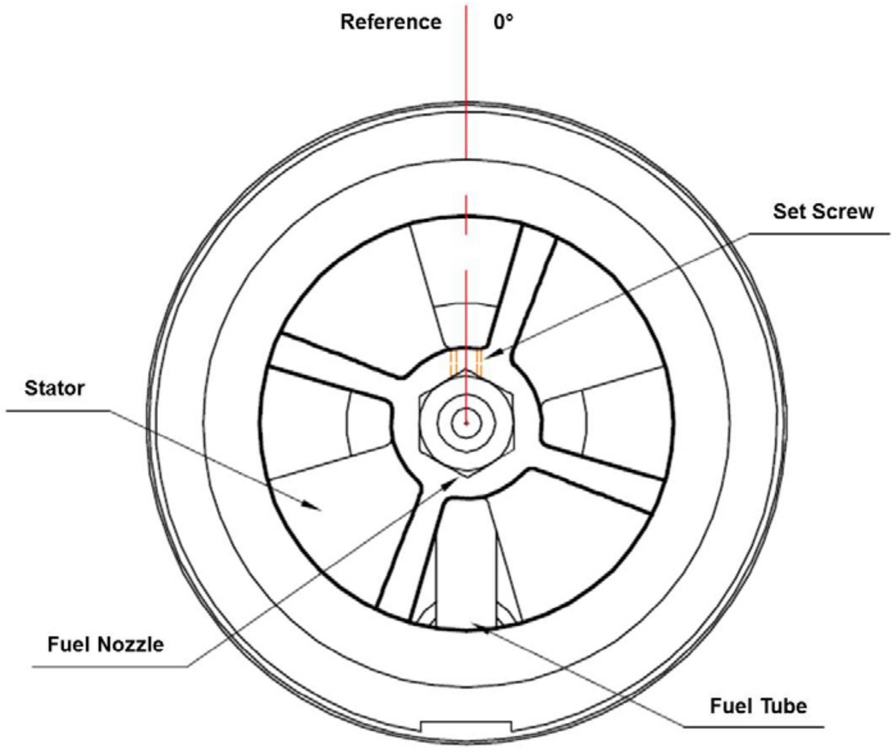


Figure A3-12. Stator axial position

A3.5.4.3 Spark Plug

A high-voltage oil-burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone.

A3.5.4.3.1 Spark Plug Gap

The spark plug gap (distance) between the two electrodes must be 0.100 inch (2.5 mm), as shown in figure A3-13.

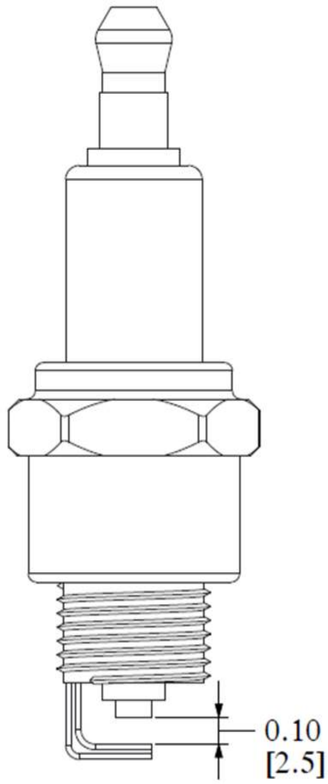


Figure A3-13. Spark plug gap measurement

A3.5.4.3 Spark Plug Wire Routing

The length and arrangement of the spark plug wire must be monitored to prevent heat damage during flame-temperature validation and testing. Once the burner is ignited, the outside surface temperature of the burner cone will increase rapidly, becoming capable of damaging the wire if it comes in contact with the cone. The spark plug wire should be carefully routed to prevent contact with the cone or other hot surfaces and should also be shielded in a heat-resistant covering to further protect it from convective heat damage from the burner flames. The wire can be routed as shown in figure A3-14, in which it does not contact any components in the vicinity of the burner cone.

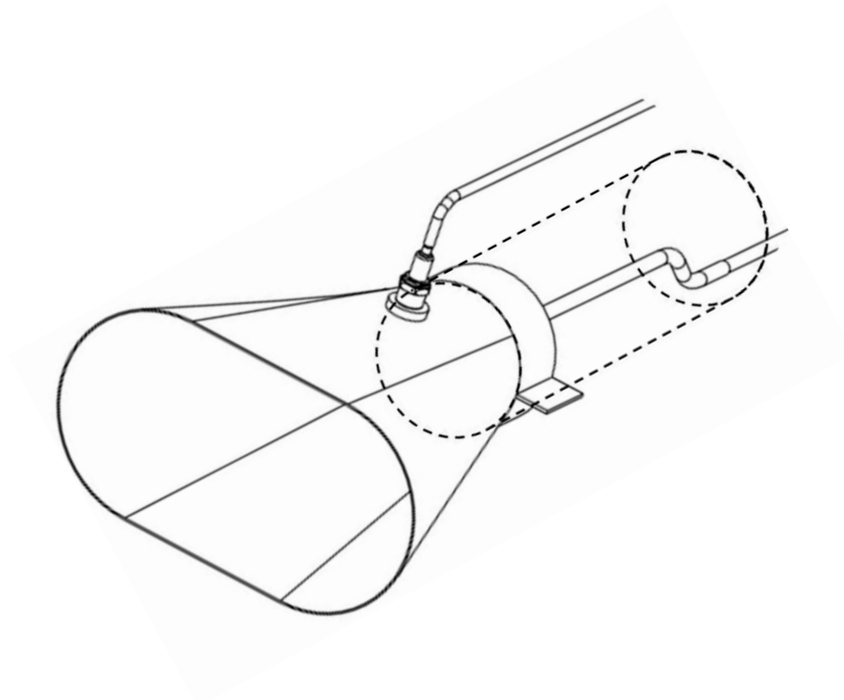


Figure A3-14. Proper routing of the spark plug wire

A3.5.4.4 Volumetric Airflow Control

The volumetric airflow is controlled via a regulated sonic nozzle. Adjust the upstream supply air pressure to 45 ± 1 lb/in^2 (0.31 ± 0.007 MPa). The intake air temperature must be maintained within the range of 40^{o}F to 60^{o}F (4^{o}C to 16^{o}C). For more details, refer to appendix K, section K.3.2, Combustion Air Control.

A3.5.4.5 Fuel Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon tubing and an appropriately sized graduated cylinder. Slip the Tygon tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon tubing into a small bucket or other collection basin. Turn on the fuel solenoid, making sure the ignition system is off. After establishing a steady stream of fuel flow, simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Do not disturb or move the tube while collecting fuel in the graduated cylinder. Collect the fuel for a 2-minute period, making certain to immediately remove the graduated cylinder from the fuel stream at precisely 2 minutes. Calculate the flow rate, and ensure that it is 2 ± 0.1 gal/hr (7.57 ± 0.38 L/hr). If the flow rate is not within the tolerance, adjust the fuel pressure accordingly. Record the fuel pressure necessary to achieve the required fuel flow. The recorded fuel pressure must be monitored and maintained during burner operation and fluctuate no more than ± 2 lb/in^2 (± 0.0138 MPa) during flame-consistency validation and sample testing. A flame-temperature validation or sample test will be void should the fuel pressure fluctuate outside of this range during either procedure. The temperature of the fuel must be maintained within the range of 32°F–52°F (0°C –11°C).

NOTE: It is important to establish a steady stream of fuel before starting the fuel-flow measurement process. It is recommended the fuel flow steadily from the hose for a minimum 10-second period before collecting fuel in the graduated cylinder.

A3.6 Burner Flame Consistency Validation

A3.6.1 Sonic Burner

The sonic burner used in the test must be checked to ensure the proper flame temperature is being produced for consistent and accurate test results.

A3.6.1.1 Move the test-sample apparatus from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of combustion products, such as soot. Soot buildup inside the cone may affect the flame characteristics and cause flame temperature validation difficulties. Check to ensure burner cone dimensions are within specified tolerances before flame validation.

A3.6.1.2 Mount the thermocouple rake on a movable stand that can be quickly moved into position in front of the burner. Move the rake into the flame-validation test position and check the distance of each of the seven thermocouples to ensure that they are located 4 ± 0.125 inches (102 ± 3 mm) from the vertical plane of the burner cone exit. Ensure that the horizontal centerline of the thermocouples is offset 1 ± 0.063 inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone (see figure A3-7). Place the center thermocouple (thermocouple number 4) in front of the vertical center of the burner cone exit. Note that the movable thermocouple rake stand must incorporate detents that ensure proper centering of the thermocouple rake with respect to the burner cone so that rapid positioning of the rake can be achieved during the validation procedure. Once the proper position is established, move the thermocouple rake away, and move back into the flame-temperature validation position to recheck distances. When all distances and positions are confirmed, move the thermocouple rake away from the burner.

A3.6.1.3 While the thermocouple rake is away from the burner, turn on the spark plug, pressurized air, and fuel flow, and light the burner. Allow the burner to warm up for 2 minutes. After warmup, move the thermocouple rake into position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for 30 seconds. Remove the thermocouple rake from the flame-temperature validation position, and turn off the burner. Calculate the average temperature of each thermocouple over this period and record. Although not a requirement for testing, the recommended average temperature of each of the seven thermocouples should be 1700°F ± 100°F (927°C ± 55°C). The burner should be rechecked to ensure it is configured properly if temperatures are measured outside this recommended range. A flame that appears biased to one side, or produces significantly higher temperatures on one end of the flame validation thermocouple rake, may indicate that an adjustment of the fuel nozzle, internal stator orientation, or distance from the end of the draft tube may be necessary if the adjustments are within allowable tolerances. If no problems are found with the burner, any thermocouple reading outside this range may require replacement. It is recommended that the burner flame temperature be validated at the beginning and end of each day testing is performed.

NOTE 1: The thermocouples are subjected to high temperature durations during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases or extreme variations in temperature or no temperature reading at all are signs that the thermocouple or thermocouples are degrading or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

NOTE 2: The sonic burner is sensitive to proper alignment of the fuel nozzle. It is crucial that the fuel nozzle be aligned to the geometric center of the turbulator. A slight adjustment of the fuel tube between the stator and fuel nozzle may be required to obtain an even temperature profile across the thermocouple rake. The center point of the nozzle where the fuel exits should not deviate more than 0.0625 inch from the geometric center of the turbulator exit plane when looking into the burner draft tube. This should be performed only after checking the burner for proper configuration.

A3.7 Test Procedure

A3.7.1 Examine and clean the cone of soot deposits and debris. Remove any debris or remains of prior test samples from the test-sample apparatus.

A3.7.2 Record the weight of a seat test sample to the nearest 0.02 pound (0.01 kg). Refer to section A3.10 to determine if the test sample is considered lightweight. If so, the covering will need to be removed from each cushion sample, and the covering and the foam cushion must be weighed separately and recorded for each sample.

A3.7.3 Secure the seat test sample to the sample mounting frame. The seat back cushion assembly can be secured at the top with a 0.125-inch diameter stainless-steel rod. Reference sections A3.3.1.1.1 and A3.3.1.1.2 for guidance information on securing samples.

A3.7.4 Ensure that the vertical plane of the burner cone is at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the test sample and that the horizontal centerline of the burner cone is aligned with the horizontal centerline of the bottom cushion assembly, as shown in figure A3-2.

NOTE 1: It is important to ensure the burner cone is aligned to the horizontal assembly when testing a sample, as described in section A3.7.4. The position of the burner relative to the test-sample mounting frame may differ slightly because of dimensional tolerances.

NOTE 2: Dress cover features such as hook-and-loop closures may protrude beyond the dress covering material. The additional thickness of such features is not to be included in the 4 ±

0.125-inches (102 ± 3 mm) distance from the seat test-sample horizontal assembly to the vertical centerline of the burner cone exit plane.

A3.7.5 Move the test-sample apparatus into the warmup position so that the flame does not impinge on the mounted test sample during the warmup period. Ignite the burner and allow the flame to stabilize for 2 minutes.

A3.7.6 Begin the test by moving the test-sample apparatus into the test position, and start the timing device when the sample is fully in the test position.

A3.7.7 Expose the test sample to the burner flame for 2 minutes, and then turn off the burner. Immediately move the sample apparatus out of the test position.

A3.7.8 Terminate the test when the sample self-extinguishes. If the sample does not self-extinguish after 5 minutes from the time the burner has been turned off, observe and record the post-test weight of the sample at the 5-minute mark, then terminate the test by extinguishing the seat test sample.

NOTE: Only gaseous extinguishers should be used that do not impact the weight of the seat test-sample remains. Care should be used during extinguishment to prevent disturbing remaining seat material, which may affect the posttest weight of the sample.

A3.7.9 Immediately after test termination, determine the post-test weight of the remains of the seat sample to the nearest 0.02 pound (0.01 kg), excluding droppings.

A3.7.10 Measure the four burn lengths.

NOTE: An industry practice acceptable to the FAA for determining sample damage length, to measure burn length, has been to use an object with a dull point, such as a pencil, and scrape the dress covering. If the object used penetrates the dress covering, damage has occurred because of that area's combustion. If the dress covering is not penetrated, damage has occurred because of pyrolysis and is not considered damaged by combustion.

A3.7.11 Repeat steps A3.7.1–A3.7.10 for the remaining seat test samples.

A3.8 Report

A3.8.1 Identify and describe each sample being tested. Report the type of foam (flame retardant [FR] molded or cut), foam density if known, and manufacturer and type of FR treatment if known.

A3.8.2 Report the number of samples tested.

A3.8.3 Report the pretest and posttest weight of each seat sample, the calculated percentage weight loss of each sample, and the calculated average percentage weight for the total number of samples tested.

A3.8.4 Report each of the four burn lengths for each sample tested.

A3.8.5 Provide a record of flame-temperature validation.

NOTE: Although not required, it may be useful to record the date, time, ambient air temperature, humidity level, and any other data that may be used to study the burn characteristics of the samples.

A3.9 Requirements

A3.9.1 For each of the four burn lengths measured on each test sample, no burn length may exceed 17 inches (432 mm) on the three samples tested. Should the burn length on the underside of the horizontal (cushion) assembly of a test sample extend to the frame angle support farthest from the burner cone, it is considered to have exceeded the 17-inch burn length criteria (i.e., it has reached the side of the cushion opposite the burner, and the test sample is a failure; see figure A3-15).

A3.9.2 The individual percentage weight loss of each of the three samples tested will not exceed 10 percent.

A3.9.3 Eighty percent of the test samples must meet the criteria of paragraphs A3.9.1 and A3.9.2.

A3.9.4 In addition, the combined average percentage weight loss of all samples tested will not exceed 10 percent.

A3.9.5 If the minimum three samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experience an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

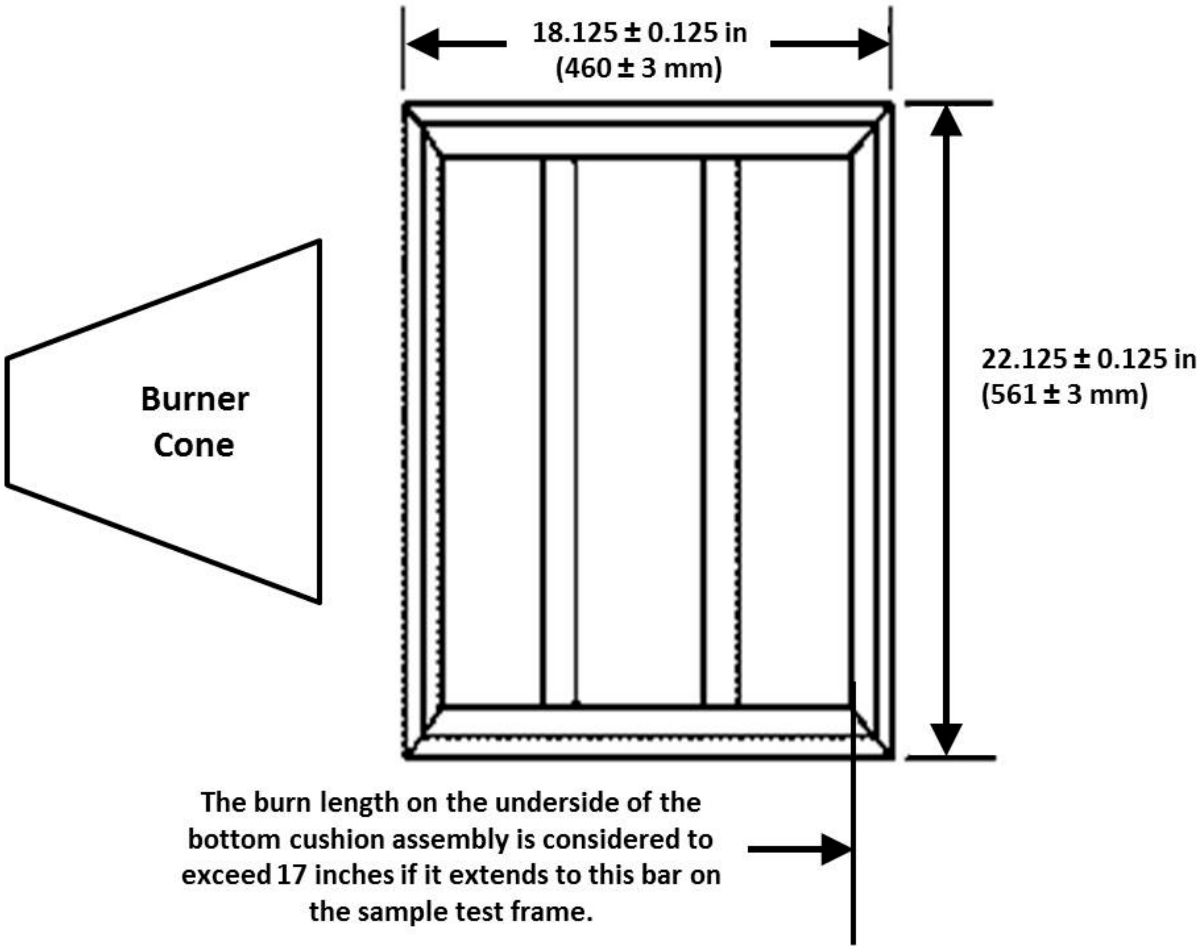


Figure A3-15. View above sample test frame bottom, indicating burn-length failure

A3.10 Requirements for Lightweight or Nonstandard Seat Test Samples

A3.10.1 A lightweight seat test sample is defined as weighing less than 3 pounds.

A3.10.2 If the total weight of the seat test sample is less than 3 pounds, the ratio of cushion weight to cover weight must be determined. The dress covers will be removed from the top and bottom foam cushion assemblies for each seat test sample so the dress covers and foam cushion assemblies can be weighed separately. The ratio of cushion weight to dress cover weight is then determined using the equation:

Ratio of Cushion Weight to Cover Weight = (Cushion Weight)/(Cover Weight)

When this ratio has been determined for each seat test sample, the average cushion-weight-to-cover-weight ratio can be calculated. The average ratio will be used to select the appropriate pass/fail criteria.

A3.10.3 See table A3-2 for pass/fail criteria. table A3-2 was taken from memo No. ANM-115-07-002, “Policy Statement on Certification for Flammability of Lightweight Seat Cushions.”

A3.10.4 For each of the four burn lengths measured on each test sample, no burn length may exceed the permissible burn length specified in table A3-2 on any of the three seat test samples tested.

A3.10.5 The individual percentage weight loss of each of the three samples tested will not exceed the permissible weight-loss percentage specified in table A3-2 corresponding to the particular seat test-sample configuration being tested.

A3.10.6 Eighty percent of the test samples must meet the criteria of paragraphs A3.10.4 and A3.10.5.

A3.10.7 In addition, the combined average percentage weight loss of all samples tested will not exceed the permissible weight-loss percentage corresponding to the particular seat test-sample configuration being tested.

A3.10.8 If the minimum three samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically met the test requirements but experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Table A3-2. Pass/fail criteria for lightweight seat test samples

Total Test-sample Weight (lb)	Average Ratio of Cushion Weight to Cover Weight	Permissible Weight Loss (%)	Permissible Burn Length (Inches)
Less than 3	1.8 to 2.0	12	16
	1.5 to 1.79	14	15
	1.1 to 1.49	16	14
	0.60 to 1.09	18	13
	0 to 0.59	20	12

Chapter A4
Test Method to Determine Heat Release Rate and Total Heat Release of Aircraft Cabin Materials

A4.1 Scope

This test method describes the determination of the heat release rates of materials and products when exposed to one level of radiant heat using the test apparatus, specimen configurations, and procedures described in this test method.

This test method is intended to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and is not used to describe or appraise the fire hazard under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment, which takes into account all of the factors relevant for an assessment of the fire hazard of a particular end use.

Heat release rate is measured for the duration of the test from the moment the specimen is injected into the controlled environmental chamber and encompasses the period of ignition and progressive flame involvement of the material.

The results of this test describe the behavior of material and product specimens due to specified fire exposure in terms of heat release rates.

A4.2 Definitions

A4.2.1 Calibration Factor (K_h)

A proportionality constant, which is determined by performing the calibration procedure described in this document. It is expressed in terms of power per degree Celsius (Watts per degree Celsius—W/°C). The calibration factor is developed by burning known flow rates of methane in the apparatus while recording the resultant thermopile temperature rise (ΔT). This process correlates the heat released by a specimen when burned to the known heat content of methane.

A4.2.2 Heat Release Rate

A measure of the rate at which heat energy is evolved by a material when burned. It is expressed in terms of power per unit area (kilowatts per square meter, kW/m^2). The maximum heat release rate occurs when the material is burning most intensely. The peak heat release rate that occurs during the 5-minute test is reported.

A4.2.3 Total Heat Release

A measure of the amount of total heat energy evolved by a material when burned. It is expressed as energy per unit area (kilowatt minutes per square meter, $kW * min/m^2$). The total amount of heat energy released during the first 2 minutes of testing is reported.

A4.2.4 Heat-Flux Density

The intensity of the thermal environment to which the specimen is exposed when burned. In this test method, the total heat-flux density is 3.21 BTU/ft^2*sec (3.65 W/cm^2).

*NOTE: Traditionally (and as specified in part IV of appendix F to part 25), the heat-flux requirement was 3.08 BTU/ft^2*sec (3.5 W/cm^2). The increase in measured irradiance is a consequence of a change in the method used to determine the heat-flux level. Previously the determination was made by inserting the calibration assembly into the heated section of the apparatus for a short period of time. The current method requires the assembly to remain in the same position until conditions become stable. This change creates some additional heating of the calibration assembly, which slightly increases the sensor's output. The parameters have been adjusted to account for this shift in output to maintain previous heat-flux levels and help improve reproducibility. The test itself is no more severe.*

A4.2.5 Thermopile

The temperature of the air entering and exiting the chamber is continuously monitored. Once baseline temperature is determined, an increase in exit gas temperature is known to be directly proportional to the heat released by a burning material. Integrating such data over a given period of time yields the total amount of heat released during that period.

A4.2.6 Mass Flow Controllers

Accurate, reliable gas flow delivery and control are crucial to this test method. Mass flow controllers (MFCs) provide precision measurement and control of airflow through the apparatus and gas flow for calibration (methane) and pilot burner operation (methane and air).

A4.2.7 Methane Gas (CH4)

Methane gas is used as a fuel for an upper and lower pilot burner, and as a calibration gas. For the purpose of this test method, the methane gas must have a minimum purity of 99% and be regulated to a supply pressure of 20 ± 2 psig from the supply cylinder.

The main air supply and air used to mix with methane gas for the upper and lower pilot flamelets must also be regulated to the controllers/flow meters at 20 ± 2 psig.

A4.2.8 National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) (USA).

A4.2.9 NIST Traceability

A calibration entity using NIST traceable calibration instrumentation.

A4.2.10 Stability

The term "stable," as it relates to heat-flux density and chamber equilibrium, is calculated using a moving average and expressed in terms of percent standard deviation over a defined period of time. Typically, stable conditions can be achieved between 60 and 90 minutes after heating has begun.

Heat flux (60-second moving average)

Heat-flux gauge (HFG) millivolt signal that varies less than 1.0% standard deviation during the last 60 seconds and having a calculated heat-flux density that is within range (see section A4.6).

Chamber equilibrium (15-minute moving average)

Thermopile temperature signal that varies less than 1.0% standard deviation during the last 15 minutes commencing no sooner than 30 minutes after turning the heating elements on.

A4.2.11 Standard Temperature and Pressure (STP)

For the purpose of this test method, STP is 0ºC at 760 mmHg (Torr) unless otherwise stated.

A4.3 Principle of the Method

A4.3.1 General

The test method is used for the determination of the heat release of component parts or subassemblies of aircraft interior.

A4.3.2 Details of the Method

The specimen to be tested is injected into an environmental chamber through which a constant flow of air passes. A radiant heat source evolves the desired total heat flux to which the specimen is exposed. The specimen is tested with the exposed surface in the vertical direction. Combustion may be initiated by point ignition on the surface or piloted ignition of evolved gases. The calculation of the heat release rate is based on the changes in temperature of the gas entering and leaving the apparatus.

A4.4 Apparatus

A4.4.1 Heat Release Rate Apparatus

This test method uses the Ohio State University heat release rate apparatus to determine heat release rates. This is a modified version of the heat release rate apparatus standardized by the ASTM (ASTM E906) (see figure A4-1).

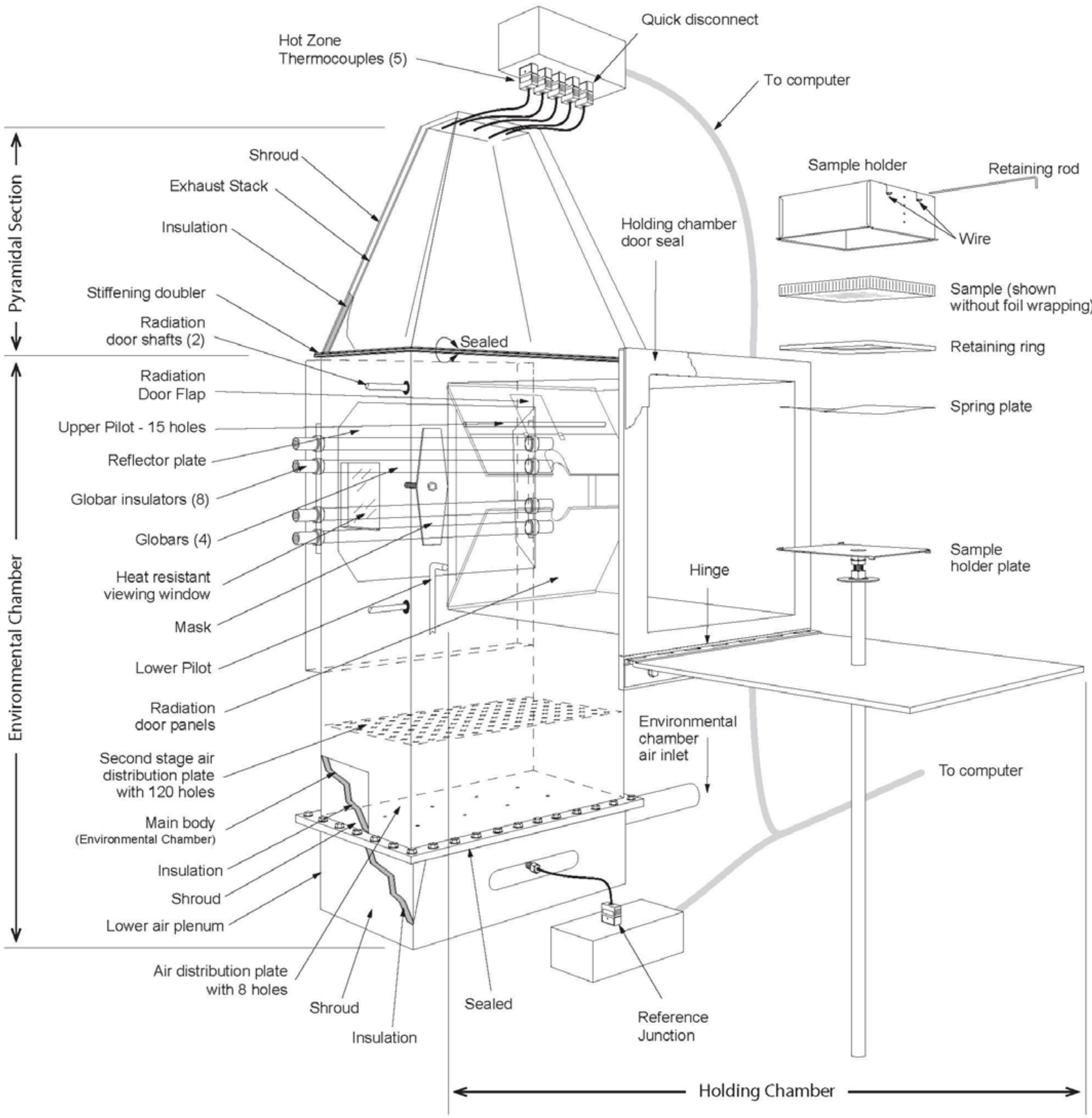


Figure A4-1. Heat release rate apparatus

The apparatus has three main sections:

1. Holding chamber
2. Environmental chamber
3. Pyramidal section

All exterior surfaces of the apparatus, except the holding chamber, must be insulated with 1-inch-thick, low-density, high-temperature insulation having a thermal conductivity (K-value) of 0.23 BTU*in/(hr*ft^2*°F) ± 10%. A thin aesthetic sheathing material or shroud used to conceal the insulation is permissible.

Formed seams, butt joints, and corner joints are recommended in the construction of the apparatus, including specimen holders. With the exception of the exhaust stack, lap joints in construction are permitted but not to exceed 0.375 inches and kept to a minimum.

A4.4.1.1 Holding Chamber

The holding chamber of the apparatus acts as an antechamber, in which the specimen is held (in the specimen holder) prior to being injected into the environmental chamber. The specimen injection rod slides through the outer door of the holding chamber having a snug fit to avoid air leakage. The door is sealed to form an airtight closure and is hinged to make a rapid injection easier and, therefore, prevent excessive heat loss.

A4.4.1.2 Environmental Chamber

The environmental chamber contains radiant heating elements known as globars, a reflector plate and diamond-shaped mask to aid in heat-flux uniformity, an upper pilot burner to ignite any surplus combustible residues released during the test, a lower pilot burner to initiate combustion of the specimen, air distributor plates that provide a constant laminar flow of air through the apparatus, and a lower plenum that contains the air inlet port and cold junction of the thermopile. The area between the air distributor plates is commonly referred to as the interspace area.

The environmental chamber also contains a two-part, hinged, insulated radiation door assembly that separates the holding chamber from the environmental chamber. The doors are constructed of two sheets of 0.030 ± 0.003-inch stainless steel with a layer of 0.25-inch rigid refractory board in between. The doors have an overall thickness of approximately 0.31 inches with a horizontal overlap where they meet in the center and a door flap to cover the injection rod-hole opening.

To provide a view for observation, there is a 4 ± 0.5-inch by 4 ± 0.5-inch heat-resistant window located on one side of the chamber. A sealed hinged-type access is permissible and will help to improve accessibility for maintenance work and cleaning.

A4.4.1.3 Pyramidal Section

The pyramidal section acts as a chimney or exhaust stack to the environmental chamber. Sensors measure the average exhaust gas temperature as it exits the system. This section is fastened to the environmental chamber using 28 #10-32 by 0.75-inch machine screws, washers, and nuts distributed around the perimeter flange. A stiffening doubler and gasket is required to form an airtight seal.

The exhaust stack must be constructed using formed seams, butt joints, or corner joints. No lap joints are permitted. A covering or shroud made of 0.036 ± 0.003-inch aluminum must be used to conceal and protect the exhaust stack insulation (see appendix L, figure 7). Aside from insulation, nothing can be attached to or in contact with the pyramid-shaped exhaust that could impact heat release data or impede the gas flow from exiting the system, including thermopile support bracketry. No substitutions are permitted in this area.

A4.4.2 Apparatus Components

A4.4.2.1 Radiation Source

A power supply capable of producing 12 kVA has been shown to be satisfactory. The radiation source must be adequately protected from variations in the power supply. A device for monitoring the voltage and current through each globar during testing must be provided. Line voltage fluctuations to the globars shall not exceed +/- 1.0%.

The radiant heat source consists of four silicon carbide elements—20-inches in length (L), 0.63-inch diameter (D), 12-inch central hot zone (CHZ)—with two low resistivity cold ends and a total nominal resistance at 1000°C of 1.4 Ohms ± 15%. The use of globar sets of similar amperage ratings is recommended to aid in even heat distribution across the test specimen.

The silicon carbide heating elements are mounted in a 2-inch deep stainless-steel pan by inserting them through 0.63-inch holes in ceramic insulating devices or calcium-silicate millboard.

A stainless-steel, truncated, diamond-shaped mask 0.042 ± 0.004-inches thick and a stainless-steel reflector plate 0.036 ± 0.003-inches thick are added to provide uniform heat flux over the area occupied by the vertical sample. The vertical mask position and the sloped areas of the plate, top and bottom, which are 3.15 inches in length, can be adjusted for this purpose. A 0.5-inch diameter machine screw or equivalent, approximately 4 inches in length, is used to mount the mask into position. Typically, the mask position is located approximately 3 inches from the reflector plate. Locate the shaft head or nut on the side of the mask facing the specimen (no threads extending toward specimen).

Variable control of power to the upper and lower globar pairs or each individually allows for refined heat-flux uniformity adjustments. Extreme care must be taken not to alter the uniformity while making minor daily heat-flux adjustments (see sections A4.6.1 and A4.6.2).

Because of extreme temperatures in the globar pan area behind the globars, 1-inch-thick refractory board may be used in place of insulation on the exterior wall (see section A4.4.1).

A4.4.2.2 Thermopile

The temperature difference between the air entering and leaving the apparatus is continuously monitored by a thermopile constructed of Type K - chromel (nickel-chromium alloy)/alumel (nickel-aluminum alloy) material. The chromel wire is generally yellow in the USA and green in Europe; the alumel wire is red in the USA and white in Europe. Check the color coding of the thermocouple wire used to ensure correct usage.

The components of the thermopile consist of five hot zone thermocouples, one reference thermocouple (cold junction), and an extension harness leading to a data-acquisition system.

The six thermocouples are 0.0625 ± 0.007 inches in diameter, not exceeding 12 inches in length with stainless-steel sheathing. They have an exposed bead junction (ungrounded) 0.030 ± 0.006 inches in diameter and a quick disconnect connection. The distance from the end of the temperature sensing tip to the sheathing shall not exceed 0.125 inches.

The hot zone thermocouples are located 0.394 inches (10 mm) below the top of the exhaust stack (see figure A4-2). One of the thermocouples is placed at the center of the exhaust stack cross section, and the other four are placed on the exhaust diagonals 1.18 inches (30 mm) from the center thermocouple. To protect the connectors from excessive heat rising from the globars, the thermocouples must be positioned above the holding chamber side of the exhaust stack.

The Type K extension harness will connect the five hot zone thermocouples and the reference thermocouple to the data-acquisition system. The wiring is 24-gauge solid conductor thermocouple-grade wire with quick disconnect connections on each end to accommodate the thermocouples.

A leak-tight connection is required for the reference junction thermocouple where it enters the lower plenum. The thermocouple sensing tip is geometrically centered in the plenum below the air-distribution plate. Sealed access ports may be provided to facilitate periodic inspection, cleaning, and maintenance.

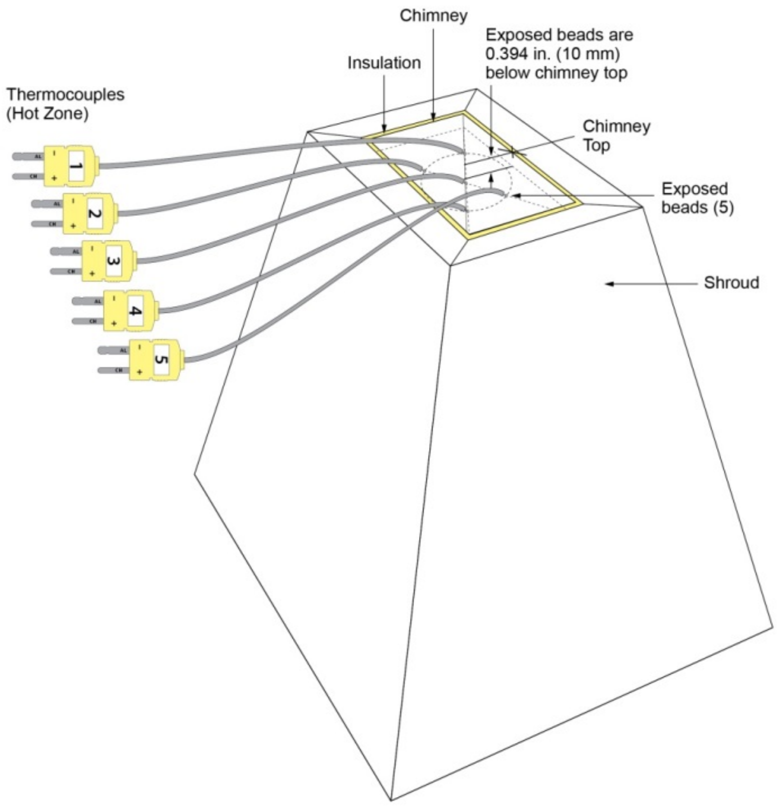


Figure A4-2. Hot zone thermocouples

A4.4.2.2.1 Calculation of Thermopile Temperature Output

The thermopile temperature is calculated as the temperature differential (ΔT) between the air entering and leaving the chamber. Each of the five hot zone thermocouple inputs is recorded and the average value is determined. The reference junction temperature is then subtracted from the average hot zone temperature to calculate the temperature rise of the thermopile signal. Annual calibration of each thermocouple and temperature input (DAQ) is required. Accuracy must be within ± 1% of 380°C.

A4.4.2.3 Lower Pilot Burner

The lower pilot burner is constructed from stainless-steel tubing with a nominal OD of 0.25 inches and a wall thickness of 0.03 inches (see figure A4-3). The normal position of the end of the pilot burner tubing is 0.394 inches (10 mm) from and perpendicular to the exposed vertical surface of the specimen. The centerline at the outlet of the burner tubing must intersect the vertical centerline of the sample at a point 0.197 inches (5 mm) above the lower exposed edge of the specimen (see appendix L, figure 16).

A mixture of 120 ± 5 milliliter/minute (mL/min) of methane and 70 ± 5 mL/min of air (STP of 21°C/1 atm.) must be fed to the lower pilot burner (via panel mounted flow meters). The test is invalidated if there is any period of time longer than 3 seconds when the flamelet is not burning.

NOTE: Pilot-burner flow settings are referenced to sea-level conditions. Facilities located at higher elevations shall adjust flow accordingly. When adjusted properly, these flow settings produce a pointed, luminous inner-cone flame approximately the same length as the OD of the burner tube (0.25 inches) and a dim outer cone approximately 0.5 inches in length.

Figure A4-3. Lower pilot-flame profile (shown with electronic igniter)

A4.4.2.4 Upper Pilot/Calibration Burner

The upper burner serves a dual purpose: an upper pilot burner to ignite off-gassing products during testing and a calibration burner for the calibration process (see sections A4.4.2.8.2 and A4.6.3).

The burner is constructed from a 15-inch length of stainless-steel tubing with an OD of 0.25 inches and a wall thickness of 0.03 inches (see figure A4-4). There are 15 holes 0.041 ± 0.0005-inches in diameter, each radiating in the same direction, drilled into the tubing. A #59 drill bit provides the proper hole diameter. The holes are spaced 0.5 inches apart with the first hole located 0.5 inches from the closed end (see appendix L, figure 17). Each hole must be completely burr-free inside and outside, but not chamfered.

The burner is inserted into the environmental chamber through a 0.25-inch hole drilled to locate the centerline of the tubing 0.875 inches above and 0.875 inches behind the upper-front edge of the specimen holder. The tubing is oriented such that the holes are directed horizontally toward the radiant heat source. One end of the tubing is closed with a silver solder plug or equivalent.

It is critical that the upper pilot burner tube is not moved out of position once set correctly. If the tube is inadvertently moved forward (toward the globars), there is a chance that a large portion of the upper pilot flames will extinguish completely in the presence of fire retardants, whereas when in the correct position, only the flame tiplets are impacted while the material is burning off. The difference between the two conditions could have a dramatic effect on the data.

When used as an upper pilot burner for testing, methane gas is set to 1.5 ± 0.03 standard liters per minute (SLPM), then mixed with air set to 1.0 ± 0.02 SLPM via the MFCs. During the test, if there is any period of time longer than 3 seconds when any three or more of the flamelets on the upper pilot burner are not burning, the test is invalidated.

NOTE: When adjusted properly, these flow settings produce upward bending blue flames, having a yellow tip (0.25 inches). The overall flame length is approximately 1inch.

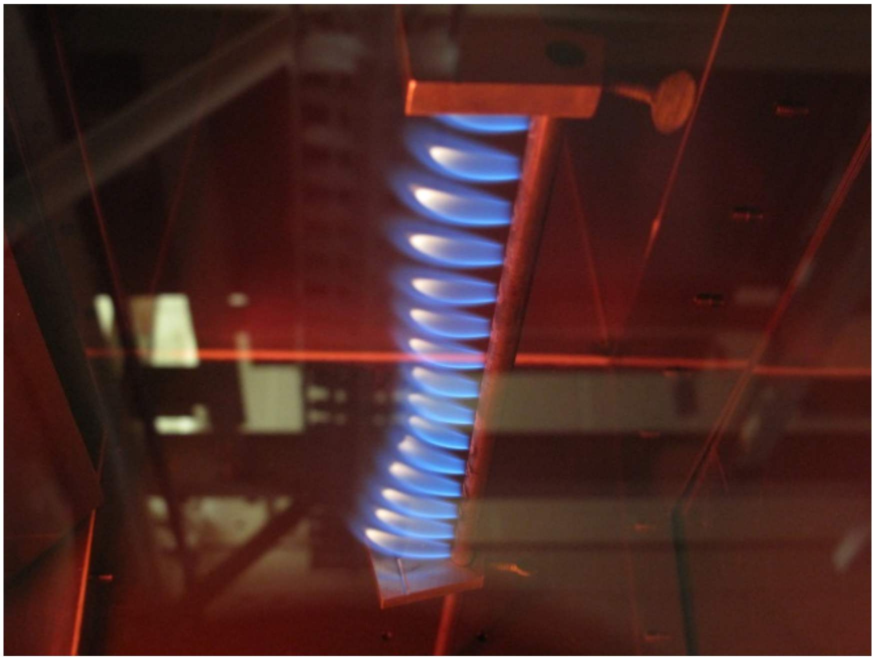


Figure A4-4. Upper pilot flame profile

A4.4.2.4.1 Upper Pilot Burner Hot Surface Igniter (HSI)

A 0.125 ± 0.005-inch diameter ceramic rod 8.0 ± 0.0625 inches in length is positioned directly in the flames of the upper pilot burner (see figure A4-5). The rod is continuously heated by the flamelets, acting as a hot-surface igniter to autoignite any upper pilot flames should they go out. The distance from the centerline of the burner tube to the centerline of the HSI rod is 0.75 ± 0.125 inches.

Two stainless-steel support brackets are mounted on the upper pilot burner tube. The brackets are separated 8.0 ± 0.0625 inches from each other (outer dimension) with one bracket aligned flush with the closed end of the burner tube. The upper pilot flames tend to curve upward because of forced airflow through the chamber and convection. To locate the HSI rod in the hottest portion of the burner flames, the brackets are rotated upward 15 ± 5° on each end. Setting the bottom of the brackets level will achieve the correct angle. It is not necessary for each bracket to be at the same angle, provided the rod is in the direct flame path across its entire length (see figure A4-6). Set screws secure the brackets in position.

The HSI rod must be cleaned or replaced when showing signs of soot buildup or wear.

Figure A4-5. Upper pilot burner HSI rod and bracket installation

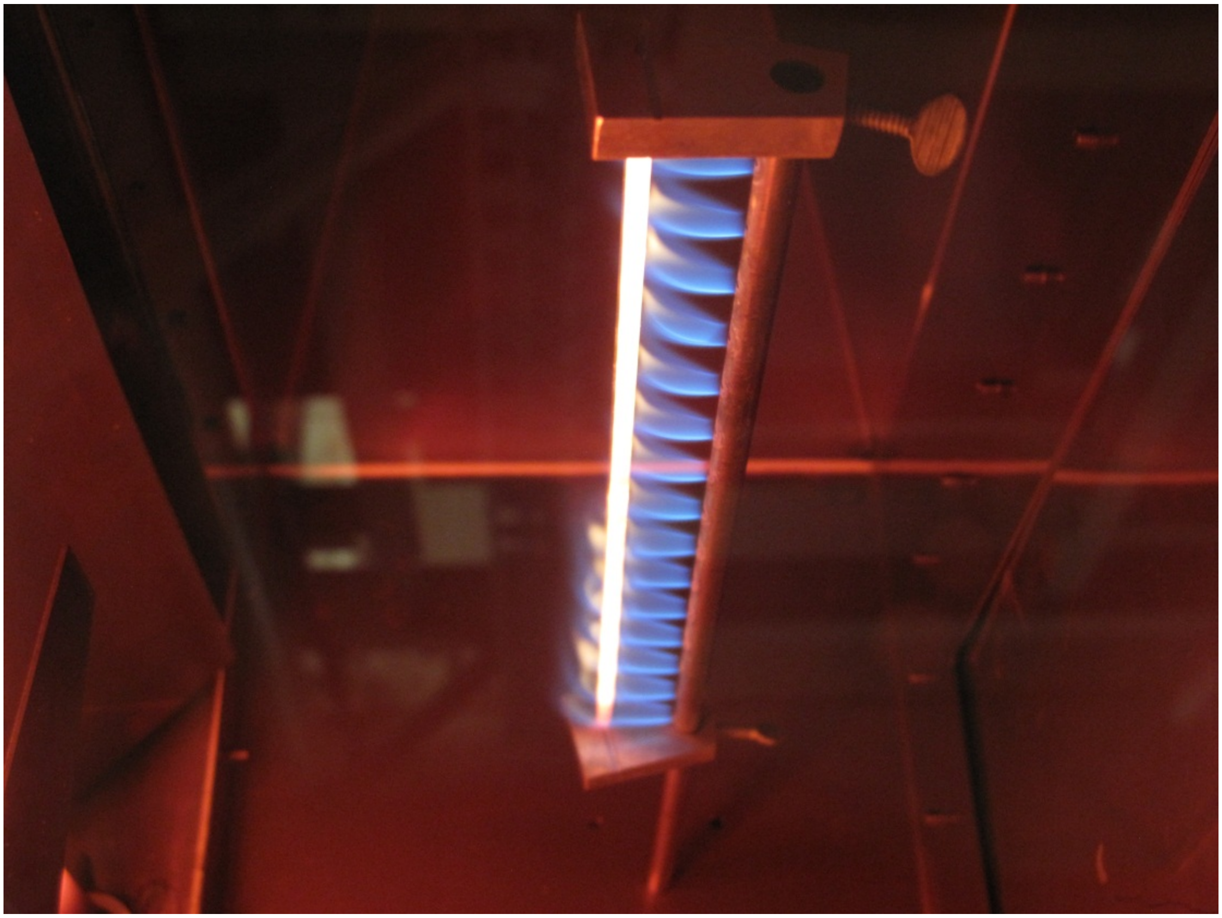


Figure A4-6. Upper pilot burner/HSI operation

A4.4.2.5 Electronic Igniter System

An igniter system for the upper and lower pilot burner is permitted to relight the flamelets to ensure they do not extinguish for more than 3 seconds during the test.

If an electric sparking device is used, an appropriate method of suppression and equipment shielding must be applied to have no interference with the ability of the data-acquisition equipment to accurately record data.

Extreme care must be taken to ensure the igniter(s) do not interfere with or shade the HFG center or corner reading while determining heat-flux levels. Also, it must not come in contact with the sample holder drip pan during testing.

A4.4.2.6 Air Distribution System

A well-regulated air supply is required. The supplied air shall be clean and free of oil mist, water (≤ 65% RH), and foreign particles.

A4.4.2.6.1 Airflow Mass Flow Controller

Airflow through the apparatus must be precisely measured and controlled using an MFC having a pressure regulated input of 20 ± 2 psig. Airflow is measured in standard cubic feet per minute (SCFM) referenced to STP 0ºC at 760 mm Hg. The flow rate through the environmental chamber is set to 20 ± 0.4 SCFM at a reference temperature of 22.5 ± 1.4°C (72.5 ± 2.5°F). The MFC is calibrated for air annually with NIST traceability. The meter shall have a minimum accuracy of ± 2% of full scale. The MFC shall have a signal output to a data-acquisition system used for monitoring airflow.

A4.4.2.6.2 Air Distribution Plate

The environmental chamber airflow enters through a nominal 1.5-inch port in the lower plenum and is distributed by a 0.25-inch thick aluminum plate having eight 0.209 ± 0.001-inch diameter holes located 2 inches from the side walls of the environmental chamber on 4-inch centers (see appendix L, figure 20). A #4 drill provides the proper hole diameter. The plate is mounted between the lower plenum and the base of the environmental chamber main body with a leak-tight connection. Each hole must be completely burr-free on each side but not chamfered.

A4.4.2.6.3 Second Stage Plate

A removable second stage plate is constructed of stainless steel 0.048 ± 0.004 inches thick and mounted 6 ± 0.25 inches above the air distribution plate.

There are 120 holes, 0.140 ± 0.001 inches in diameter. A #28 drill provides the proper hole diameter. The hole pattern is centered on the plate within the environmental chamber and spaced in rows of 15 along the long dimension at 1-inch spacing and rows of 8 along the narrow dimension at 0.875-inch spacing (see appendix L, figure21). Each hole must be completely burr-free on each side but not chamfered.

The plate is mounted such that the perimeter is sealed airtight to force all airflow through the 120 holes.

A4.4.2.7 Specimen Holder

Specimen holders are fabricated from a stainless-steel sheet 0.018 ± 0.002 inches thick. Each holder is provided with a specimen holder frame touching the specimen only along the perimeter, a V-shaped spring plate, and a retaining rod that holds the assembly together. The position of the spring pressure plate can be changed to accommodate different specimen thicknesses by inserting the retaining rod in different holes of the specimen holder. Applying equal spring plate pressure to specimens of equal thickness by inserting the specimen retaining rod in the same holes for each specimen tested is recommended.

Each holder also has 0.020-inch stainless-steel wires (2) attached vertically to the front of the holder to secure the face of the specimen in the holder. When testing, these wires are in place for all specimens (see appendix L, figure 22).

A4.4.2.7.1 Drip Pan

Drip pans are for optional use to prevent melting specimens from dripping into the lower test section of the environmental chamber. A drip pan is fabricated from a stainless-steel sheet 0.018 ± 0.002 inches thick and clipped to the specimen holder using attachment flanges (see appendix L, figures 26–27). Foil may be used to line the drip pan to facilitate cleaning after use.

A4.4.2.7.2 Holding Chamber/Injection Mechanism

The specimen holder is attached to an injection mechanism mounting plate. The plate is made of 0.036 ± 0.003-inch stainless steel, which incorporates metal locking tabs that secure the specimen holder in place. A large area washer forms a tight seal with the inner radiation doors when closed (see appendix L, figures 28–29). The sample face, when inserted into the holding chamber prior to testing, is located 9 ± 0.5 inches from the inner radiation doors.

When the sample is inserted into the environmental chamber, the front surface of the vertical specimen is parallel to the radiant heat elements and located 3.94 inches (100 mm) from the inner wall of the environmental chamber where the radiation doors close.

A4.4.2.8 Calibration Equipment

A4.4.2.8.1 HFG

Two water-cooled, Schmidt-Boelter-type HFGs, as specified in appendix H, are used to determine the total heat-flux density. One gauge is used to measure heat flux at a point where the center of the sample surface is located at the start of the test. A corner HFG is used to determine heat-flux uniformity and its centerline located diagonally 2.75 ± 0.25 inches from the center.

The HFG cooling water temperature, pressure, and flow are maintained within the manufacturer's recommendations. Ensure no condensation occurs on the gauge surface at any time (often caused by cooling water being too cold). Do not connect cooling water circuits in series. It is recommended using rigid tubing cooling water lines because of the high temperatures within the environmental chamber.

Each HFG has a thin, full-faced, opaque coating of high-temperature, high-emissivity, ultra-flat black paint. The sensitivity of the gauge is a function of the surface condition. Changes in the coating may cause drift in the overall characteristic of the gauge. Regularly inspect the measuring surface for physical damage or dust particles that may have accumulated. Cleaning can be accomplished by gently wiping a soft, water-dampened sponge across the sensor face. Damage to the coating during the cleaning process will affect the measurement accuracy of the sensor. To maintain accuracy, the measuring surface must be recoated at regular intervals, followed by recalibration (see appendix H).

The HFGs are mounted in a supporting device in a sample holder assembly or equivalent, protruding through 0.5-inch-thick rigid refractory board having a density of 50 ± 10 lb/ft^3 (800 ± 160 kg/m^3). Each gauge has a 180º field of view; therefore, the surface must be mounted flush with the insulation board and not recessed.

The gauges must be parallel to the radiant heat elements when positioned in the environmental chamber to measure heat flux. The complete assembly shall be lightweight to minimize warmup time while in use. The HFGs are calibrated annually in accordance with appendix H.

A4.4.2.8.2 Methane/Mixing Air MFCs

Thermal-based MFCs having nominal 0.25-inch inlet/outlet fittings are used to provide precision measurement and control of gas flow for the calibration process and the upper pilot burner flame during testing. The methane MFC is calibrated annually with NIST traceability for methane gas and is capable of controlling flow rates up to 4 SLPM. The meter shall have a minimum accuracy of ± 1% of full scale and is referenced to STP 0ºC at 760 mm Hg (1013 mbar). The controller must have a response time of 2 seconds or less to get within ± 2% of final value. The upper pilot burner mixing air MFC has the same requirements; however, it must be calibrated for air.

The MFCs shall have a signal output to a data-acquisition system used for monitoring gas flow. The tubing from the MFCs to the upper pilot/calibration burner must be as short as possible and direct in routing with all joints leak-tight.

A4.4.3 Data-Acquisition System/Display Devices

The data-acquisition system and indicating devices (millivolt, flow, temperature) must be calibrated annually to NIST traceability with a measurement uncertainty of less than 1.0% reading.

A4.5 Test Specimens

A4.5.1 Specimen Number

A minimum of three specimens is prepared and tested for each material/part.

A4.5.2 Specimen Size

The standard size for specimens is 5.94 + 0, - 0.06 by 5.94 + 0,- 0.06 inches in lateral dimensions. For calculation purposes, the area of the specimen is 36 in^2 (0.02323 m^2). Specimen thickness is as used in the relevant application up to 1.75 inches; applications requiring thicknesses greater than 1.75 inches will have specimens constructed and tested in 1.75-inch thicknesses.

A4.5.3 Specimen Preparation

Only one surface of a specimen is exposed during a test. A single layer of 0.0012 ± 0.0005-inch-thick aluminum foil is wrapped tightly on all unexposed sides with the dull side of the foil facing the specimen surface (see figure A4-7). The foil must be continuous and not torn. The retaining frame is placed behind the specimen between the back of the specimen and the pressure plate. After the specimen is placed tightly into the specimen holder, all aluminum foil on the exposed side is removed to avoid covering any of the exposed specimen area or obstructing airflow across the material surface. When trimming excess foil from the test specimen, care must be taken not to score or make an incision into the perimeter surface of the material.

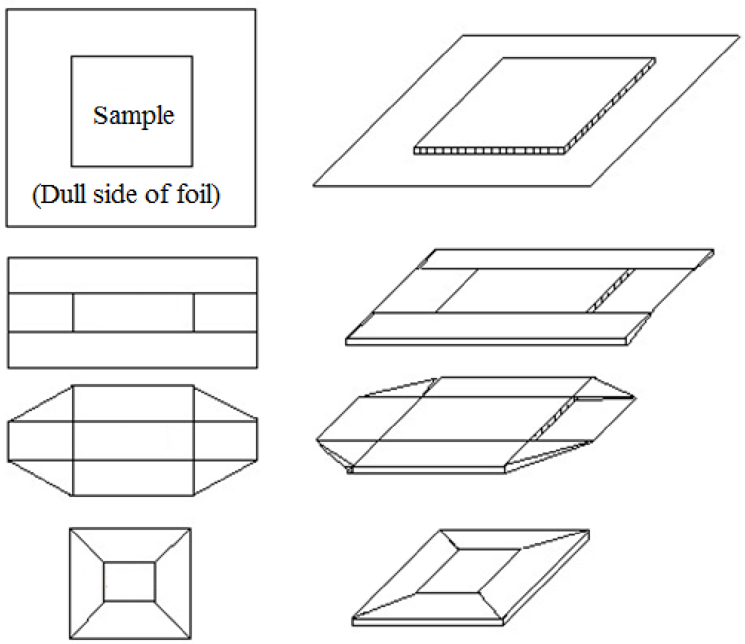


Figure A4-7. Recommended specimen foil wrapping

A4.5.4 Specimen Orientation

For materials that may have anisotropic properties (i.e., different properties in different directions, such as machine and cross-machine directions for extrusions, warp, and fill directions of woven fabrics), the specimens shall be tested in both orientations and both must pass the requirements specified under section A4.10.

A4.5.5 Conditioning

Specimens are conditioned at 21 ± 2ºC (70 ± 5ºF) and 55 ± 10% RH for a minimum of 24 hours prior to testing. The conditioning equipment shall be calibrated annually and the parameters checked daily for proper operation.

If possible, remove only one specimen at a time from the conditioning environment immediately before being tested. If this is not possible, it is acceptable to remove more than one specimen at a time if each specimen is placed in a closed container to protect it from contamination until it is subjected to the flame.

A4.6 Calibration Procedure of Equipment

A4.6.1 Heat-Flux Calibration (Center position)

For determination of total heat-flux density, a sensor is positioned at a point where the center of the specimen is located when the test is started. The center heat flux must be 3.21 ± 0.04 BTU/ft^2*sec (3.65 ± 0.05 W/cm^2) and verified daily before testing. The HFG remains exposed to the radiant heat source inside the environmental chamber, with radiation doors closed, until a stable reading is achieved (see section A4.2.10).

An adjustable stop in the insertion mechanism, together with a positioning template, should be used to ensure the HFG adopts the correct position when inserted into the chamber. This will increase the reproducibility and repeatability of the heat-flux measurement.

A4.6.1.1 Procedure

A4.6.1.1.1

Verify air and methane gas is off at the upper and lower pilots.

A4.6.1.1.2

Ensure the lower and upper pilot burners are positioned correctly.

A4.6.1.1.3

Turn on the airflow through the environmental chamber (see section A4.4.2.6).

A4.6.1.1.4

Verify cooling water is flowing to the HFGs and signal wiring is connected to the data-acquisition system (see section A4.4.2.8.1).

A4.6.1.1.5

Position and secure the HFG calibration assembly into the holding chamber, ensuring an airtight seal. Insert the HFGs into the environmental chamber hot zone, close the inner radiation doors, and begin recording the transducer millivolt outputs.

A4.6.1.1.6

Turn on power to globars and begin heating the apparatus.

A4.6.1.1.7

The HFGs remain exposed to the radiation heat source inside the environmental chamber until a stable reading of 3.21 ± 0.04 BTU/ft^2*sec (3.65 ± 0.05 W/cm^2) is achieved (see section A4.2.10 Stability).

A4.6.1.1.8

If the heat flux is unacceptable, adjust the power and wait for the heat flux to restabilize (see section A4.4.2.1). Repeat this procedure until an acceptable heat-flux level is obtained.

A4.6.2 Heat-Flux Uniformity Calibration (Corner Positions)

Uniformity of heat flux is determined by heat-flux sensor measurements at each of the four corners of the specimen surface. The heat flux at each corner must be 3.21 ± 0.09 BTU/ft^2*sec (3.65 ± 0.1 W/cm^2). The heat-flux uniformity checks shall be carried out daily when testing and after each repair or maintenance of radiant heat source components. Some examples include (but are not limited to): the replacement of globars, wiring terminal connections, insulator devices, reflector plate, or diamond-shaped mask including mounting hardware. Additional examples include repair or replacement of the globar power supply or its components, and recalibration of HFGs, data-acquisition system and display devices.

A4.6.2.1 Procedure

A4.6.2.1.1

Conduct the heat-flux calibration procedure (see section A4.6.1).

A4.6.2.1.2

Once complete, start with any one of the four corner measurements and determine the heat-flux level.

A4.6.2.1.3

Open inner radiation doors, return the HFG assembly to the holding chamber, and rotate 90 degrees.

NOTE: Extreme care must be taken during this step not to make contact with the upper pilot tube. Do not rotate the calibration assembly until it is fully withdrawn into the holding chamber. Ensure it has been rotated a full 90 degrees before reinserting into the environmental chamber.

A4.6.2.1.4

Reinsert the assembly back into the chamber and close the doors. Allow time to restabilize and record heat-flux level. Repeat this process for the remaining corners.

A4.6.2.1.5

The heat flux at each corner must be 3.21 ± 0.09 BTU/ft^2*sec (3.65 ± 0.1 W/cm^2).

NOTE: Adjustments can be made to improve the heat-flux uniformity by varying the power settings accordingly, repositioning the globars (in appearance) hottest to coolest starting from the bottom position, moving the diamond-shaped mask closer to or farther from the center HFG (in and out), sliding the globars left or right, or by adjusting the reflector plate slope top and bottom as needed.

A4.6.2.1.6

If adjustments were necessary during this procedure, the center heat flux shall be rechecked before continuing.

A4.6.3 Determination of the Calibration Factor (K_h)

The calibration factor shall be determined weekly when testing and additionally after each repair or maintenance of the apparatus that may have an influence on heat-release results. Some examples include (but are not limited to): the replacement of apparatus insulation or sheathing; recalibration of MFCs, HFGs, data-acquisition system or display devices; and the replacement of thermopile or radiant heat components.

Prior to calibration, airflow through the unit is verified to be correct and maintained within the specified temperature range. Calibration can begin once the heat flux is determined to be within range and the system has achieved the stability criteria (see section A4.2.10). Methane gas is directed to the upper pilot/calibration burner for calibration of the thermopile. The methane gas is pure and not diluted with air. Calibration is conducted with the HSI installed, the sample injection mechanism withdrawn into the holding chamber, and all doors closed.

To begin, the zero gas flow data point is recorded by allowing the system to stabilize for 4 minutes averaging the final 20 second values of the thermopile. Gas flow is considered to be 0 SLPM.

Next, methane gas is permitted to flow to the calibration burner, the doors are opened, and the burner is lit. Alternately, an igniter may be used for remotely lighting the burner without opening the doors. Within 10 seconds of ignition, all doors are closed, gas flow to the burner is set to 3 SLPM, and a 4 minute stabilization of the chamber begins. As an overall systems check, the final 20 second average thermopile temperature is calculated as the thermal stability temperature (TST), and must be 380 ± 15°C (716 ± 27°F). Difficulties achieving the TST criteria may be indicative of system air leakage, thermopile malfunction or misalignment, HFG malfunction, misalignment or improper calibration, or MFC malfunction or improper calibration (main airflow or methane gas control).

The 20 second average thermopile temperature and corresponding average MFC gas flow rate are recorded, and the calibration factor is determined (see section A4.6.3.2). Immediately after the conditioning period has lapsed, gas flow to the burner is shut off.

If the burner flames were lit but a calibration restart is necessary, there must be a 15-minute waiting period for the system to reset before a new calibration can be attempted (no flames lit; doors closed).

A4.6.3.1 Calibration Procedure

A4.6.3.1.1

With a soft brush or quick blast of shop air, clean the upper thermocouples (hot junctions of the thermopile), and check their position using a handheld template. For a more thorough cleaning, ethyl alcohol may be used with the soft brush.

A4.6.3.1.2

With a soft brush, remove soot buildup from the exhaust stack inner walls.

A4.6.3.1.3

Vacuum the environmental chamber and second-stage plate.

A4.6.3.1.4

Turn on the exhaust-hood ventilation system.

A4.6.3.1.5

Isolate the upper and lower pilot air and methane gas supplies (methane gas to the upper pilot/calibration burner is turned on in A4.6.3.1.9).

A4.6.3.1.6

Verify proper airflow/temperature. Conduct the heat-flux calibration procedure as necessary (see sections A4.6.1 and A4.6.2).

A4.6.3.1.7

Remove the HFG calibration assembly. Close all doors, ensuring the sample injection mechanism remains withdrawn into the holding chamber.

A4.6.3.1.8

Allow proper warmup time for MFC as recommended by the manufacturer.

A4.6.3.1.9

Turn on methane gas and ensure correct supply pressure to the MFC (see section A4.2.7)

A4.6.3.1.10

With no gas flowing, start the calibration program. Allow the system to stabilize for 4 minutes and determine the final 20 second average thermopile temperature.

A4.6.3.1.11

With methane gas flowing, open the doors, light the burner, then close the doors.

A4.6.3.1.12

Ensure gas flow is set to 3 SLPM. Begin a 4 minute countdown.

A4.6.3.1.13

Calculate the final 20-second average TST (380 ± 15°C) and gas flow.

A4.6.3.1.14

Immediately shut off gas.

A4.6.3.1.15

Determine the calibration factor.

A4.6.3.2 Calculation of Calibration Factor K_h

The heat of combustion of methane or higher heating value (HHV) is briefly defined as the amount of heat released when a unit amount of gas is completely combusted. For this test method, the heating value of methane is determined using the lower heating value (LHV). The LHV assumes that any water in the combustion products is not condensed and remains as a vapor (Hv). The relation between the HHV and the LHV is expressed as:

LHV = HHV – Hv

where:

$$\text{Combustion reaction} = CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Heat of combustion of methane (HHV) = 210.8 kCal

Heat of vaporization of $2H_2O$ (Hv) = 22 kCal

Calculate the calibration factor K_h by generating a least squares fit (slope) of flow rate vs. thermopile temperature data points (L/°C). Insert the slope into the equation below to determine the calibration factor (W/°C).

$$K_h = \frac{(210.8 - 22)\ \text{kCal}}{\text{mole}} * \frac{\text{mole}\ (CH_4\ \text{STP})}{22.41\ \text{L}} * \frac{\text{WATT} * \text{min}}{0.01433\ \text{kCal}} * \frac{\Delta \text{Flow}}{\Delta\ \text{Temperature}} \quad \text{W/°C}$$

Simplifying this gives:

K_h = 587.91 * Slope W/°C

Example: (Assuming 3 SLPM Methane flow @ 103.7 °C delta T)

K_h = 587.91 * 0.0289 = 17 W/°C

The calibration factor K_h must be 17 ± 2 W/°C.

If the TST or the calibration factor is out of range, ensure that the stability requirements have been met (see section A4.2.10), there are no air leaks, and all equipment and components of the apparatus are functioning/calibrated properly. Once confirmed, repeat the complete calibration procedure.

A4.7 Preparation/Test Procedure

A4.7.1 Preparation

A4.7.1.1

Clean the upper thermocouples (hot junctions of the thermopile) if necessary and check their position using a handheld template.

A4.7.1.2

Remove any debris that may have settled on the second-stage air-distribution plate.

A4.7.1.3

Check the position of the injected sample holder with the pilot burners by using a positioning tool and an adjustable stop on the insertion mechanism.

A4.7.1.4

Turn on exhaust hood system.

A4.7.1.5

Ensure correct airflow through the apparatus (see section A4.4.2.6).

A4.7.1.6

Set the power supply to the globars to produce a total heat-flux density of 3.21 ± 0.04 BTU/ft^2*sec (3.65 ± 0.05 W/cm^2).

NOTE: The thermopile baseline temperature must be carefully observed during daily testing. Changes in the baseline temperature can be an indicator of developing problems, such as variations in heat flux (HFG malfunction), defects in the thermopile, or air leakage in the environmental chamber/lower plenum, exhaust stack, or holding chamber door seal. Additionally, there is the possibility of the inlet airflow MFC not functioning properly. It is good practice to also monitor daily globar power control settings.

A4.7.1.7

Turn on methane gas and mixing air to ensure correct supply pressure (see section A4.2.7).

A4.7.1.8

Light the upper and lower pilot flames and check gas flow and respective flame profile (see A4.4.2.3 and A4.4.2.4).

A4.7.1.9

Close all doors.

A4.7.1.10

Allow the system time to restabilize with burners lit for 15 minutes before testing.

A4.7.1.11

Activate the spark igniter(s) if used.

A4.7.1.12

Ensure the HSI is positioned correctly (see section A4.4.2.4.1).

A4.7.1.13

Prepare the specimen for testing (see section A4.5.3).

A4.7.1.14

If needed, attach the drip pan to the specimen holder (see section A4.4.2.7.1).

A4.7.2 Test Procedure

A4.7.2.1

Ensure the radiation doors are closed.

A4.7.2.2

Within approximately 10 seconds, open the holding chamber door, place the specimen holder on the mounting plate, close the door, and start the recording device.

A4.7.2.3

Keep the specimen in the holding chamber for 60 seconds. Record, at least once a second, the thermopile temperature output during the final 20 seconds of the hold time before the specimen is injected, and report the average as the baseline thermopile reading ($\mathrm{Baseline}_{\circ C}$).

NOTE: Extreme caution must be used to ensure that the baseline reading is completed prior to opening inner doors for sample injection.

A4.7.2.4

After recording the baseline reading and within a timeframe not exceeding 5 seconds, open the radiation doors, inject the specimen into the environmental chamber, and close the doors. Record the thermopile temperature output ($\mathrm{Thermopile}_{\circ C}$) at least once a second for the duration of the test.

A4.7.2.5

Watch the burning process and record any observation of melting, sagging, dripping, delaminating, or other behavior that affected the exposed surface area or mode of burning and the time (in seconds) at which such behavior occurred.

A4.7.2.6

Watch the pilot flames during the test. If the lower pilot burner was extinguished for a period longer than 3 seconds or at least 3 of the upper pilot flames were extinguished simultaneously for any period of time exceeding 3 seconds, mark this test run as invalid.

NOTE: The use of an externally positioned mirror or camera may assist in viewing upper pilot flames during testing.

A4.7.2.7

After the test has been running for 5 minutes, open the radiation doors, return the specimen to the holding chamber, and close the radiation doors.

A4.7.2.8

When ready to remove the sample, open the holding chamber door, remove the specimen holder from the mounting plate, and close the door.

Caution: Hot and toxic gases could be present!

A4.7.3 Preparation of Further Test Runs

Wait until the baseline temperature has restabilized before beginning another test. Depending on the construction of the material or its burning intensity, wait times may vary. For dripping materials or products that fall to the lower plate during testing, debris must be removed from the chamber prior to the next test.

Clean the upper thermocouples of soot after each set of specimens (3–5 specimens) has been tested using a small, soft-bristled brush or quick blast of shop air. A more frequent cleaning may be required for materials that produce heavy soot. Ensure that the thermocouples are in their proper position before proceeding with the next specimen; a handheld template may be used to facilitate this step. For a more thorough cleaning, ethyl alcohol may be used with the soft brush.

A4.8 Presentation of Results

For all specimens tested, determine and record the maximum heat release rate during the 5-minute test. Also, compute and record the total heat released during the first 2 minutes of testing by integrating the heat release rate over time. When calculating the total heat release, only positive heat release rate values are included in the summation.

A4.8.1 Heat Release Rate

At a data-collection frequency of 1 Hz or 1 scan per second, calculate the heat release rate for any point in time during a test from the reading of the thermopile temperature output at that time using:

$$\text{Heat Release Rate} = (\text{Thermopile}_{\circ\text{C}} - \text{Baseline}_{\circ\text{C}}) * \left(\frac{\text{K}_\text{h} \div 1000}{0.02323\ \text{m}^2}\right) \quad \text{kW/m}^2$$

where K_h and $\text{Baseline}_{\circ\text{C}}$ are the calibration factor and average thermopile temperature at the baseline, respectively.

A4.8.2 Total Heat Release

Using this formula, the total heat release (kW * min/m^2) as a function of time (in minutes) based on the integral of the heat release rate can be determined:

$$\text{Total Heat Release} = \int_0^2 (\text{Thermopile}_{\circ\text{C}} - \text{Baseline}_{\circ\text{C}}) * \left(\frac{\text{K}_\text{h} \div 1000}{0.02323\ \text{m}^2}\right) (t)dt \quad \text{kW * min/m}^2$$

Simplifying this gives:

$$\text{Total Heat Release} = \frac{\sum_{t=0}^{n-1} (\text{Thermopile}_{\circ\text{C}} - \text{Baseline}_{\circ\text{C}}) * \left(\frac{\text{K}_\text{h} \div 1000}{0.02323\ \text{m}^2}\right)}{x} \ \text{kW * min/m}^2$$

where:

n = Total number of data collection points in 2 minutes.

x = Total number of data collection points in 1 minute.

$\text{Baseline}_{°C}$ = Average thermopile temperature reading at baseline (°C).

$\text{Thermopile}_{°C}$ = Thermopile temperature reading at any point during test (°C).

K_h = Calibration factor (W/°C).

Sample area = Total calculated area of test specimen (m^2).

NOTE: This formula uses the Riemann Left-Hand Sum method of integration (t=0).

A4.9 Accuracy, Units, and Rounding

For the purpose of this test method, all values are rounded up (see Table A4-1). If the next place beyond where a digit is terminated is greater than or equal to 5, the terminating digit is increased by a value of 1 and the digits to the right are dropped off (e.g., 25.476 accurate to the hundredths place is rounded up to 25.48).

Unless otherwise stated, the following shall apply:

Table A4-1. Accuracy, Units, and Rounding

Accuracy	Description	Units
Tenths place (e.g., x.x)	Peak heat release rate	kW/m^2
	Time to peak	Sec
	2-minute total heat release	$kW * min/m^2$
	Heat release rate	kW/m^2
	Temperature	°F /°C
	Relative humidity	% RH
Hundredths place (e.g., x.xx)	Heat flux	W/cm^2
	Airflow	SCFM
	Calibration factor	W/°C
	Methane gas flow	SLPM
Ten thousandths place (e.g., x.xxxx)	Slope (used for calibration factor)	L/°C
Hundred thousandths place (e.g., x.xxxxx)	Sample area	m^2

A4.10 Requirements

A4.10.1 Quantity of Samples

A minimum of three samples must be tested, and 80% or greater must pass both criteria specified in A4.10.1.1 and A4.10.1.2.

A4.10.1.1 Peak Heat Release Rate (kW/m^2)

The maximum heat release rate during the 5-minute test will not exceed 65 kW/m^2.

A4.10.1.2 Initial 2-Minute Total Heat Release ($kW * min/m^2$)

The total heat released during the first 2 minutes will not exceed 65 $kW * min/m^2$.

A4.11 Test Report

A4.11.1

Report the laboratory conducting the tests.

A4.11.2

Fully identify the material tested.

A4.11.3

Graphically report the heat release rate (kW/m^2) at 1 hertz (Hz) as a function of time (in seconds) for each test.

A4.11.4

Report the maximum heat release rate and time (in seconds) it occurs during each test.

A4.11.5

Report the total heat released during the first 2 minutes of each test.

A4.11.6

Report the radiant heat flux to the specimen.

A4.11.7

Report the calibration factor $K_h (W/°C)$.

A4.11.8

Report the average baseline temperature for each specimen tested.

A4.11.9

Report any melting, sagging, dripping, delaminating, or other behavior that affected the exposed surface area or mode of burning that occurred and the time (in seconds) at which such behavior occurred.

A4.11.10

Report total number of materials tested and total number of materials that passed.

Table A4-2. Nominal operating parameters/ranges

PARAMETER	DESCRIPTION	MIN	NOMINAL	MAX
Inlet Airflow Rate	SCFM	19.6	20	20.4
Inlet Air Temperature	°C	21.1	22.5	23.9
Inlet Air Relative Humidity	% RH	-	-	$\leq$ 65
Heat Flux (W/cm^2)	Center	3.60	3.65	3.70
	Each Corner (4)	3.55	3.65	3.75
Average Baseline Exhaust Gas Temperature	No Flame (°C)	270	280	290
Calibration Factor Range	Slope (L/°C)	0.0255	0.0289	0.0323
	W/°C	15.00	17.00	19.00
	kW/m^2/°C	0.646	0.732	0.818
	3 SLPM ΔT (°C)	92.8	103.7	117.6
Interspace Pressure	inH2O	0.40	0.55	0.70
Lower Plenum Pressure	inH2O	11.0	12.5	14.0
Methane Gas Supply Pressure	PSIG	18	20	22
Main Air Supply Pressure	PSIG	18	20	22
Mixing Air Supply Pressure	PSIG	18	20	22
Thermal Stability Temperature (TST)	20 sec average (°C)	365	380	395
Specimen Conditioning	Temperature (°C)	18	21	24
	Relative Humidity (%)	45	55	65
Upper Pilot Gas Flow	Air (SLPM)	0.98	1.00	1.02
	Methane (SLPM)	1.47	1.50	1.53
Lower Pilot Gas Flow	Air (mL/min)	0.65	0.70	0.75
	Methane (mL/min)	115	120	125

NOTE: When not a requirement, the values in this table may be used as a guide for system performance. Not all parameters listed are absolute or required but may help identify underlying problems that may be present.

Chapter A5
Test Method to Determine the Burnthrough Resistance of Thermal/Acoustic Insulation Materials

A5.1 Scope

A5.1.1 Applicability

This test method evaluates the burnthrough resistance characteristics of aircraft thermal/acoustic insulation materials when exposed to a high-intensity open flame.

A5.2 Definitions

A5.2.1 Burnthrough Time

Burnthrough time means the time, in seconds, for the burner flame to penetrate the test sample or the time required for the heat flux to reach 2.0 Btu/ft^{2}sec (2.27 W/cm^2) on the inboard side, at a distance of 12 inches (30.5 cm) from the front surface of the insulation blanket test frame, whichever is sooner. The burnthrough time is measured at the inboard side of each of the insulation blanket samples.

A5.2.2 Insulation Blanket Sample

Insulation blanket sample means one of two samples positioned in either side of the test rig at an angle of 30 degrees with respect to vertical.

A5.2.3 Sample Set

Sample set means two insulation blanket samples. Both samples must represent the same production insulation blanket construction and materials, proportioned to correspond to the sample size.

A5.3 Apparatus

A5.3.1 Test Apparatus

The arrangement of the test apparatus is shown in figures A5-1 and A5-2 and must include the capability of moving the test samples into and away from the sonic burner. Construct the mounting frame for the test samples of 0.125-inch-thick (3.2 mm) steel, as shown in figure A5-1, except for the center vertical former, which should be 0.25-inch thick (6.4 mm) to minimize warpage. The sample mounting frame stringers (horizontal) should be bolted to the test frame formers (vertical) so the expansion of the stringers will not cause the entire structure to warp. Use the mounting frame for mounting the two insulation blanket test samples, as shown in figure A5-2.

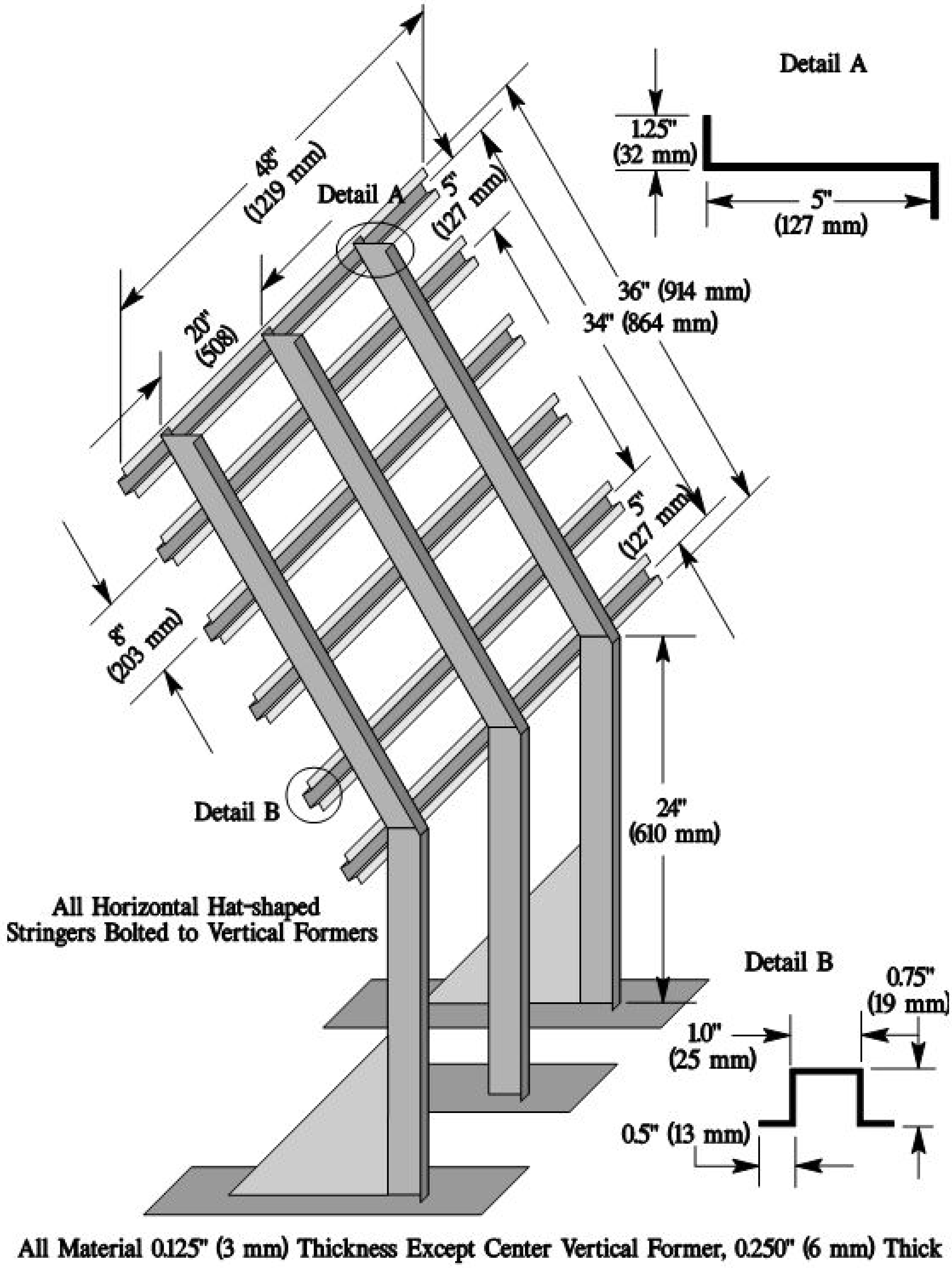


Figure A5-1. Test apparatus sample holder

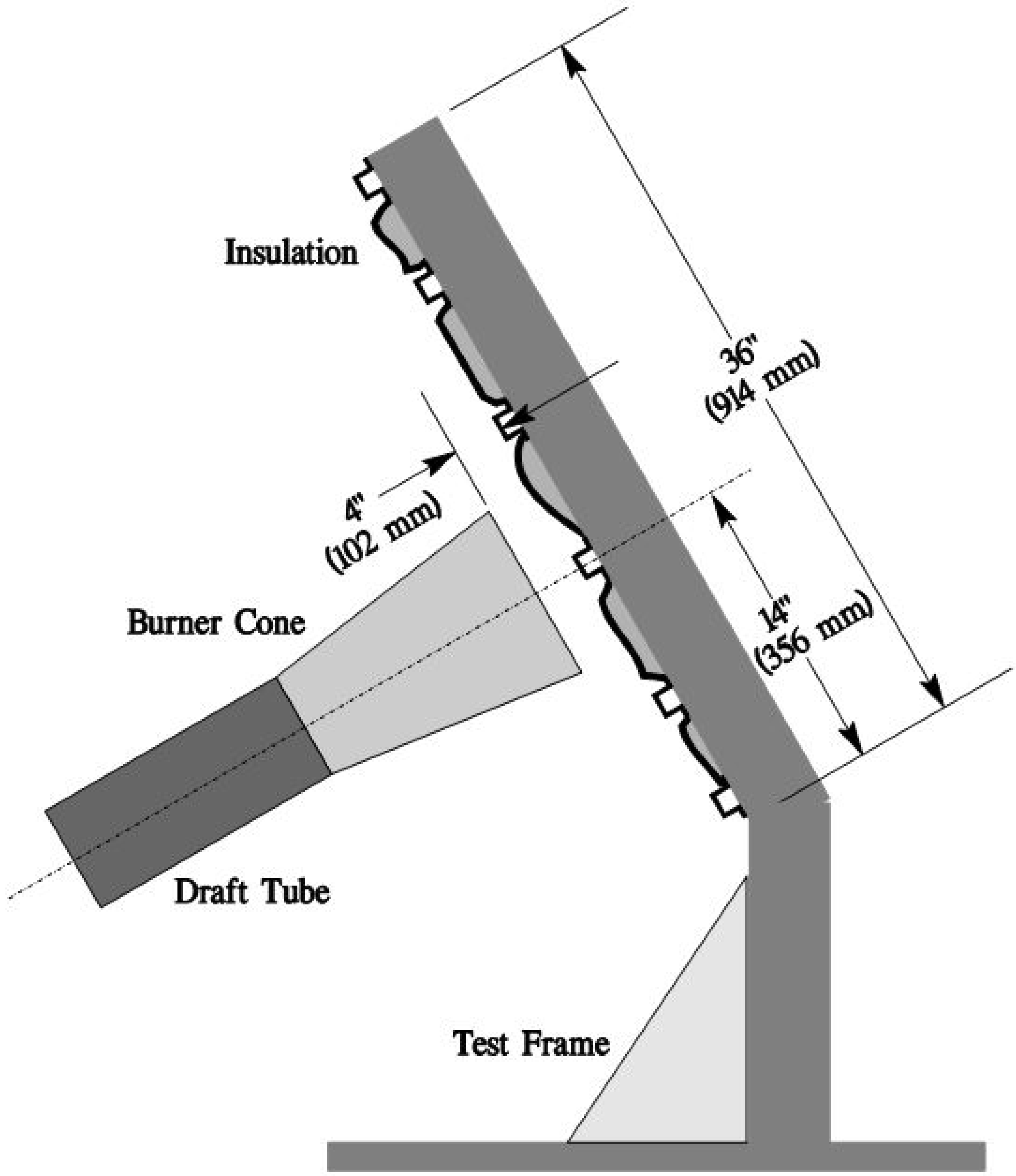


Figure A5-2. Burnthrough test apparatus sample holder

A5.3.2 Burner

The test burner is the Sonic fire test burner, described in detail in appendix K. The burner configuration for this test method is displayed in table A5-1.

Table A5-1. Burner configuration for the insulation burnthrough test

Fuel	Nozzle	6.0 gal/hr 80° Solid Spray
	Volumetric Flow Rate (gal/hr)	6.0 ± 0.2
	Pressure	110 ± 10
Air	Diffusion Method	Stator and Turbulator
	Pressure (psig)	65 ± 2
	Mass Flow Rate (SCFM)	65.8
	Burner Orientation	30° From Horizontal

A5.3.2.1 Inlet Condition Measuring

To obtain an accurate measurement of the conditions entering the burner, fuel pressure and temperature, and air pressure and temperature measurements must be made nearest to the burner inlet (see figure A5-3). To minimize air-stream disruptions, the intake air temperature must be measured prior to the sonic nozzle.

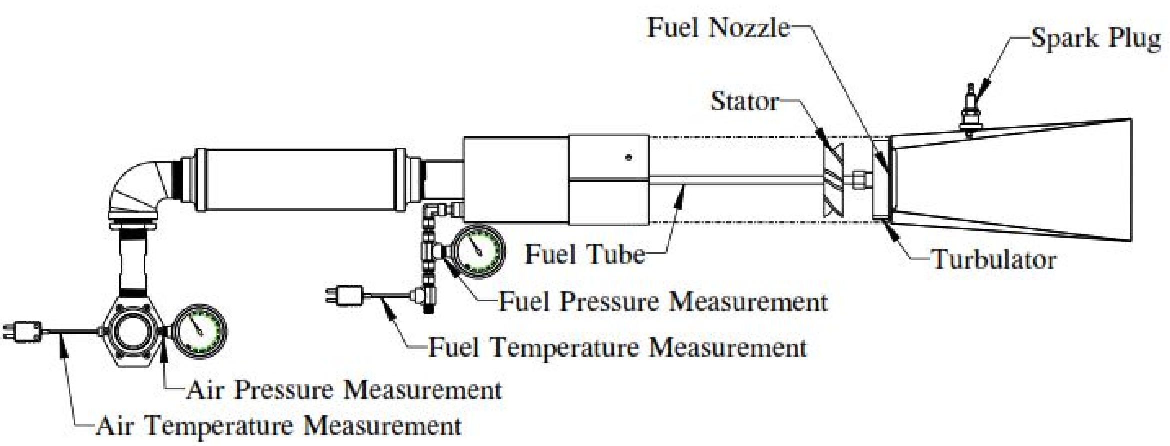


Figure A5-3. Inlet condition measurement location (side view)

A5.3.2.2 Fuel Nozzle

A screw-in fuel nozzle is required to maintain a fuel pressure that will yield a 6.0 ± 0.2 gal/hr (22.68 L/hr ± 0.756 L/hr) fuel flow. A nozzle with an 80° solid spray angle nominally rated at 6.0 gal/hr (22.68 L/hr) at 100 lb/in^2 (0.69 MPa) has been found to deliver the appropriate flow rate and produce the proper flame pattern. Actual flow-rate measurements may deviate from the advertised flow rate. The actual flow rate must be measured manually using a flexible tube, graduated cylinder, and timing device, as described in section A5.5.4.6. The fuel pressure must then be adjusted accordingly to produce the required fuel flow of 6 ± 0.2 gal/hr (22.68 L/hr ± 0.756 L/hr). For more details, refer to appendix K, section K.3.4.4, Fuel Nozzle.

A5.3.2.3 Fuel Pressure Regulation

The fuel must be properly pressurized to deliver the proper fuel flow. Ideally, this pressure must be in the range of 100–120 lb/in^2 (0.69 to 0.83 MPa). For details on fuel pressurization and regulation, refer to appendix K, section K.3.4, Fuel System.

A5.3.2.4 Fuel Type

A kerosene-type fuel is used in the burner equipment. Jet A and JP-8 (military equivalent to Jet A) fuel is recommended; however, other fuels are permissible if the flame temperature can be maintained, according to section A5.6.1.3. For more details, refer to appendix K, section K.3.4.6, Fuel.

A5.3.2.5 Burner Cone

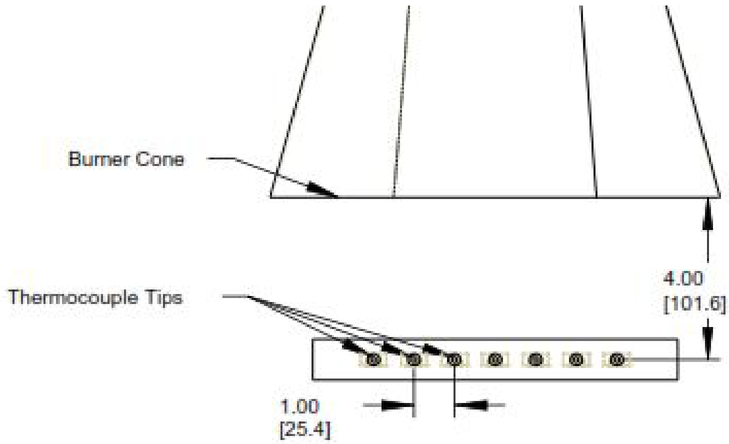
A 12 ± 0.125-inch (305 ± 3-mm) burner extension cone is fitted to the end of the burner draft tube. The opening must be 6 ± 0.125 inches (152 ± 3 mm) high and 11 ± 0.125 inches (280 ± 3 mm) wide. For more details, refer to appendix K, section K.3.7, Burner Cone.

A5.3.2.6 Spark Plug

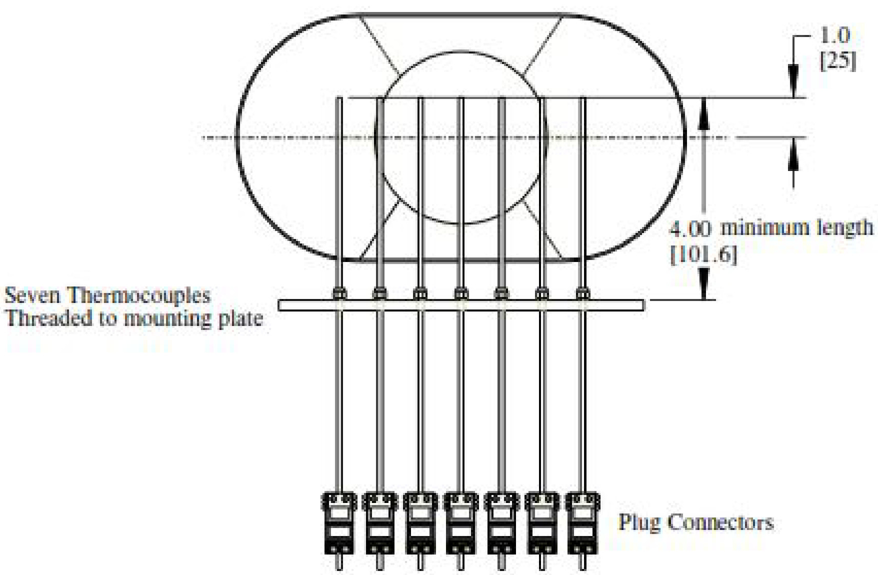
An automotive-style spark plug is fitted into a threaded boss, which is welded to the burner extension cone. The threaded boss is centered on the upper surface of the burner cone at a distance of 6 ± 0.125 inches (152 ± 3 mm) from the intake end of the burner cone. For more details, refer to appendix K, section K.3.5, Ignition.

A5.3.3 Burner Flame Consistency Validation Thermocouples

Seven thermocouples must be used to check the flame temperature of the burner. The thermocouples must be 0.125-inch (3.2-mm) diameter, insulation-packed, 310 stainless-steel sheathed, type K (Chromel-Alumel), grounded junction with a nominal 24 American Wire Gauge (AWG) size conductor. Thermocouples purchased with a certificate of calibration may provide more accurate readings but are not required. The seven thermocouples must be attached to a steel mounting plate to form a thermocouple rake for placement in the test stand during the burner flame consistency validation procedure (see figure A5-4). It is recommended the thermocouple mounting plate be a minimum of 4 inches (102 mm) away from the tips of the thermocouples.



Top View



Side View

Figure A5-4. Top and side view of thermocouple rake bracket

A5.3.4 Backface Heat Flux Gauges

Mount two total heat-flux, Gardon-type gauges behind the insulation test samples on the back side (cold) area of the test-sample mounting frame, as shown in figure A5-5. Position the backface heat flux gauges (HFGs) along the same plane as the burner cone centerline, at a distance of 4 inches (102 mm) from the vertical centerline of the test frame.

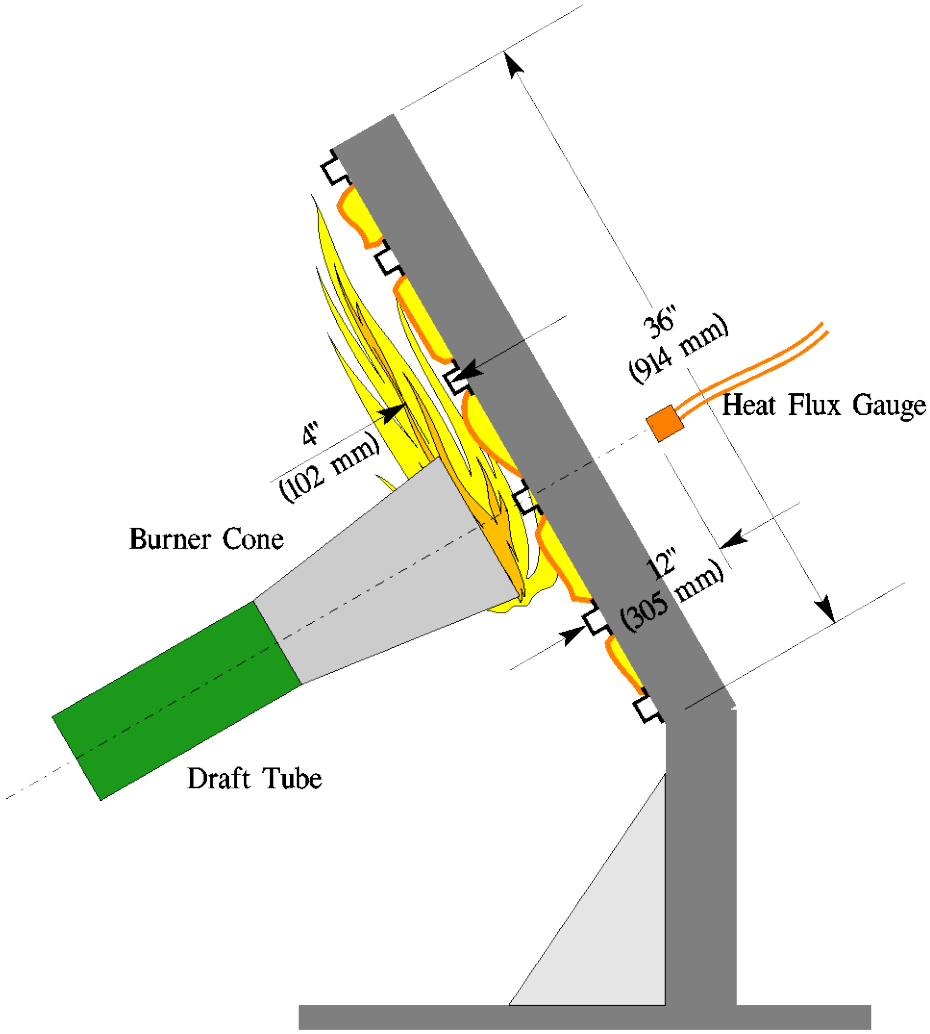


Figure A5-5. Position of backface HFGs relative to test-sample frame

A5.3.4.1 Backface HFG Requirements

The HFGs must be a total heat flux, foil-type Gardon gauge of an appropriate range, such as 0-5 Btu/ft^2-sec (0-5.7 W/cm^2), accurate to ± 3% of the indicated reading. The heat-flux calibration method must comply with the requirements of appendix H.

A5.3.5 Instrumentation and Supporting Equipment

A5.3.5.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the outputs of the thermocouples and HFGs.

A5.3.5.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame, the test-sample ignition, and the extinguishment times.

A5.3.5.3 Test Chamber Anemometer

A handheld vane-type or hotwire-type air velocity sensing unit capable of measuring accurately in the 0–100 ft/min range must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating. Airflow measurements should be taken at the beginning of the day prior to operating the test burner. A suitable hotwire anemometer, which may be mounted to the sample test frame, is manufactured by Dwyer® Instruments, model number 641-6-LED. A suitable handheld hotwire anemometer is manufactured by TSI, model number 9515. Vane-type anemometers typically do not function properly with airflow rates less than 50 ft/min.

A5.3.5.4 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. Although not required, the recommended minimum of the test-chamber floor area is 15 feet by 15 feet (4.57 m by 4.57 m) or larger.

NOTE: Smaller test cells may experience significant increases in ambient air temperature while testing. This may increase the severity of the test.

A5.3.5.5 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

A5.4 Test Samples

A5.4.1 Sample Preparation

Prepare a minimum of three sample sets of the same construction and configuration for testing.

A5.4.2 Insulation Blanket Test Sample

A5.4.2.1 For batt-type materials, such as fiberglass, the constructed, finished blanket sample assemblies must be 32 inches wide by 36 inches long (81.3 by 91.4 cm), exclusive of heat-sealed film edges.

A5.4.2.2 For rigid and other nonconforming types of insulation materials, the finished test samples must fit into the test rig in such a manner as to replicate the actual in-service installation.

A5.4.3 Construction

Make each of the samples tested using the principal components (i.e., insulation, fire barrier material if used, and moisture barrier film) and assembly processes (representative seams and closures).

A5.4.3.1 Fire Barrier Material

If the insulation blanket is constructed with a fire barrier material, place the fire barrier material in a manner reflective of the installed arrangement. For example, if the material will be placed on the outboard side of the insulation material inside the moisture film, place it the same way in the test sample.

A5.4.3.2 Insulation Material

Blankets that use more than one variety of insulation (e.g., composition, density) must have sample sets constructed that reflect the insulation combination used. If, however, several blanket types use similar insulation combinations, it is not necessary to test each combination if it is possible to bracket the various combinations.

A5.4.3.3 Moisture Barrier Film

If a production blanket construction uses more than one type of moisture barrier film, perform separate tests on each combination. For example, if a polyimide film is used in conjunction with insulation to enhance the burnthrough capabilities, also test the same insulation when used with a polyvinyl fluoride film.

A5.4.4 Installation on Test Frame

Attach the blanket test samples to the test frame using 12 steel spring-type clamps, as shown in figure A5-6. Use the clamps to hold the blankets in place in both of the outer vertical formers and the center vertical former (four clamps per former). The clamp surfaces should measure 1 inch by 2 inches (25 by 51 mm). Place the top and bottom clamps 6 inches (15.2 cm) from the top and bottom of the test frame, respectively. Place the middle clamps 8 inches (20.3 cm) from the top and bottom clamps.

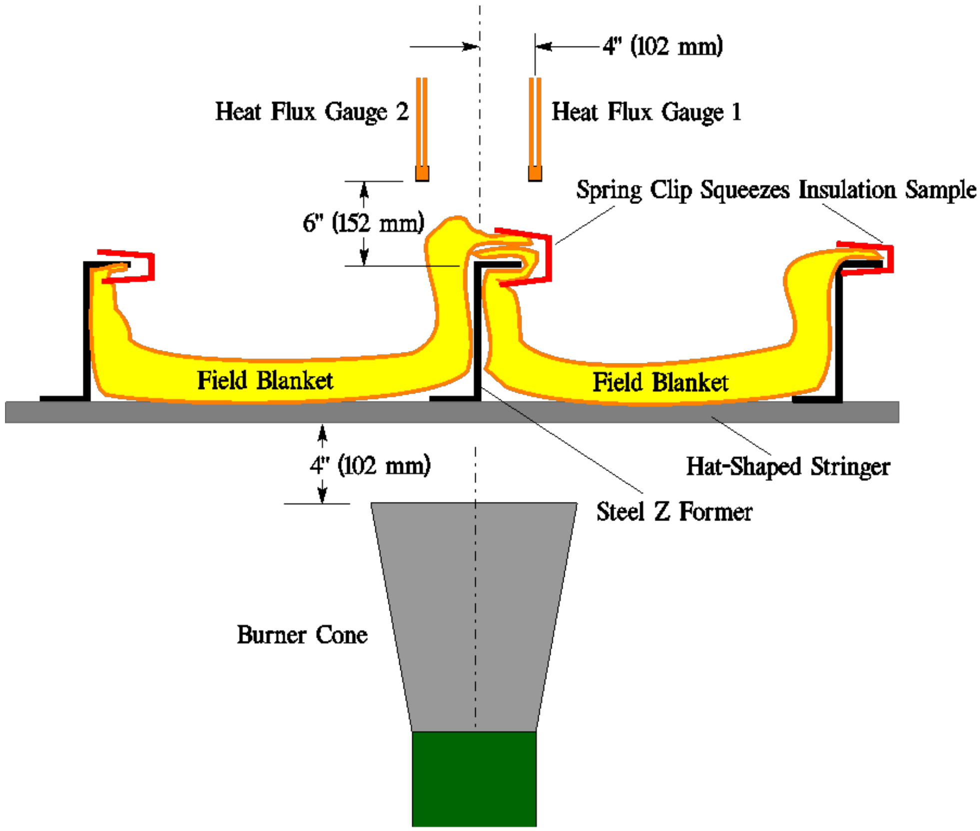


Figure A5-6. Test-sample installation on test frame

NOTE: For blanket materials that cannot be installed in accordance with figure A5-6, the blankets must be installed in a manner approved by the FAA.

A5.4.5 Conditioning

Samples must be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing. Remove only one sample at a time from the conditioning environment immediately before testing.

A5.5 Preparation of Apparatus

A5.5.1 Alignment

Mount a test sample on the test-sample frame. Level and center the sample holder frame assembly to ensure alignment with the burner cone. Move the test-sample mounting frame into position in front of the burner, and check for proper alignment (i.e., distance from exit of burner cone to face of test sample, and proper sample height with respect to cone centerline). The movable assembly should incorporate mechanical stops or detents to ensure that the samples can be moved into position quickly without measurement during testing.

A5.5.2 Chamber Ventilation

Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. With the test sample still in place on the test frame, measure the airflow in the test chamber using a hotwire anemometer or equivalent measuring device. The vertical air velocity within a 12-inch (30.5 cm) radius from any point on the test sample must be less than 100 ft/min (50.8 cm/sec). The horizontal air velocity within a 12-inch (30.5 cm) radius from any point on the sample must be less than 50 ft/min (25.4 cm/sec).

NOTE 1: Airflow measurements do not have to be taken for each sample tested. It is recommended the airflow measurements be taken at the beginning of the day before testing and at the end of the day when testing is completed.

NOTE 2: Personnel present within the test cell may influence air velocity readings. This may be avoided by mounting the anemometer instrumentation to the sample holder during test cell air velocity measurements.

A5.5.3 Test Chamber Air Temperature

The temperature of the test chamber should be between 50°F and 100°F (10°C and 38°C) before the start of each test. The chamber air temperature should be measured at the same height as the center of the test sample, within 12 inches (30.5 cm) laterally. Remove the sample from the test frame. Do not use this sample for testing. The sample may be kept for future test chamber airflow and temperature measurements.

A5.5.4 Sonic Burner Configuration

A5.5.4.1 Fuel Nozzle Location

The tip of the fuel nozzle, or fuel exit plane, must be located 0.1875 ± 0.020 inches (4.763 ± 0.5 mm) from the exit plane of the turbulator (see figure A5-7).

A5.5.4.2 Stator Adjustment

The stator is positioned by adjusting its translational position and its axial position on the fuel rod.

A5.5.4.2.1 Stator Translational Position

The front face of the stator must be located 2.6875 ± 0.020 inches (68.263 ± 0.5 mm) from the exit plane of the turbulator (see figure A5-7). This stator translational position is also 2.5 inches (63.5 mm) from the tip of the fuel nozzle.

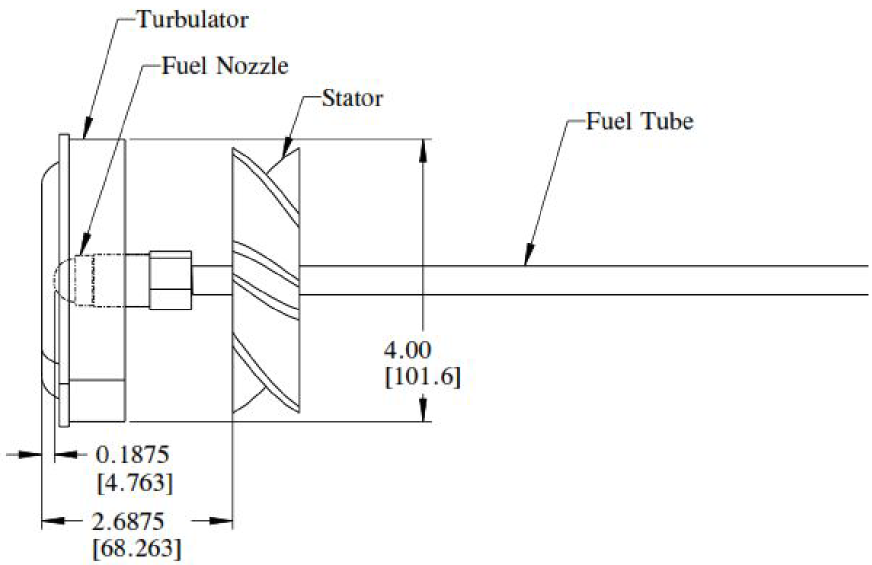


Figure A5-7. Fuel nozzle and stator locations

A5.5.4.2.2 Stator Axial Position

The line running through the set screw and geometric center of the stator will be used as a reference for properly orienting the rotational position of the stator. The stator must be positioned so the reference line angle is 0 degrees (12 o'clock) from the zero position when looking into the burner draft tube (see figure A5-8).

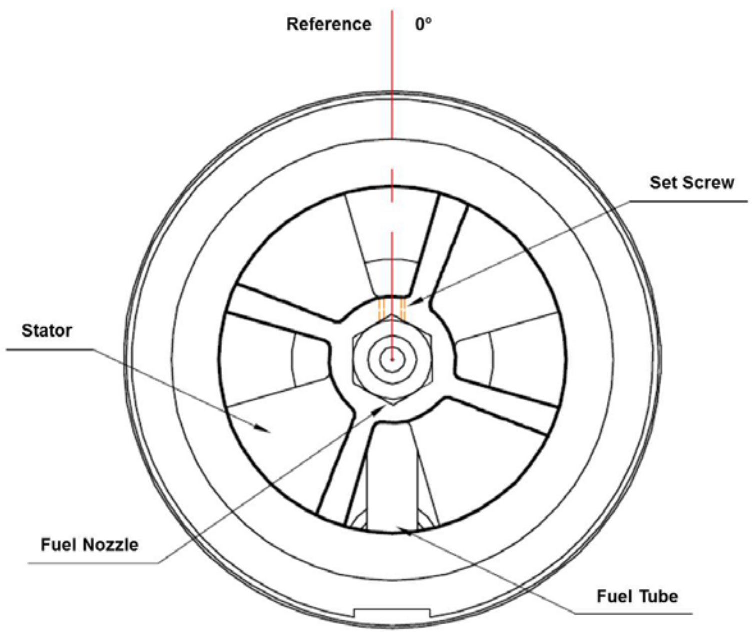


Figure A5-8. Stator axial position

A5.5.4.3 Spark Plug

A high-voltage oil burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone.

A5.5.4.3.1 Spark Plug Gap

The spark plug gap (distance) between the two electrodes must be 0.100 inches (2.5 mm), as shown in figure A5-9.

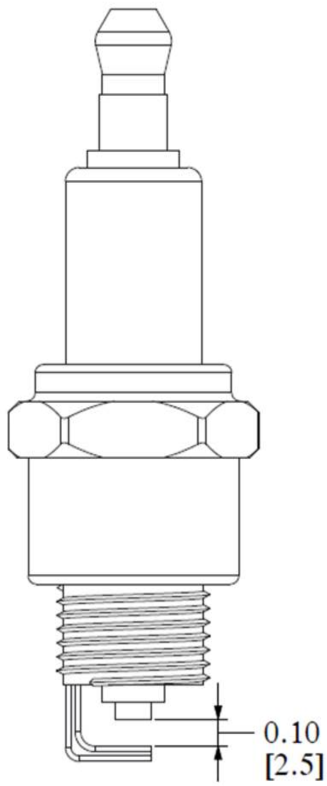


Figure A5-9. Spark plug gap measurement

A5.5.4.4 Spark Plug Wire Routing

The length and arrangement of the spark plug wire must be monitored to prevent heat damage during flame-temperature validation and testing. Once the burner is ignited, the outside surface temperature of the burner cone will increase rapidly, becoming capable of damaging the wire if it comes in contact with the cone. The spark plug wire should be carefully routed to prevent contact with the cone or other hot surfaces, and should also be shielded in a heat-resistant covering to further protect it from convective heat damage from the burner flames. The wire can be routed as shown in figure A5-10, in which it does not contact any components in the vicinity of the burner cone.

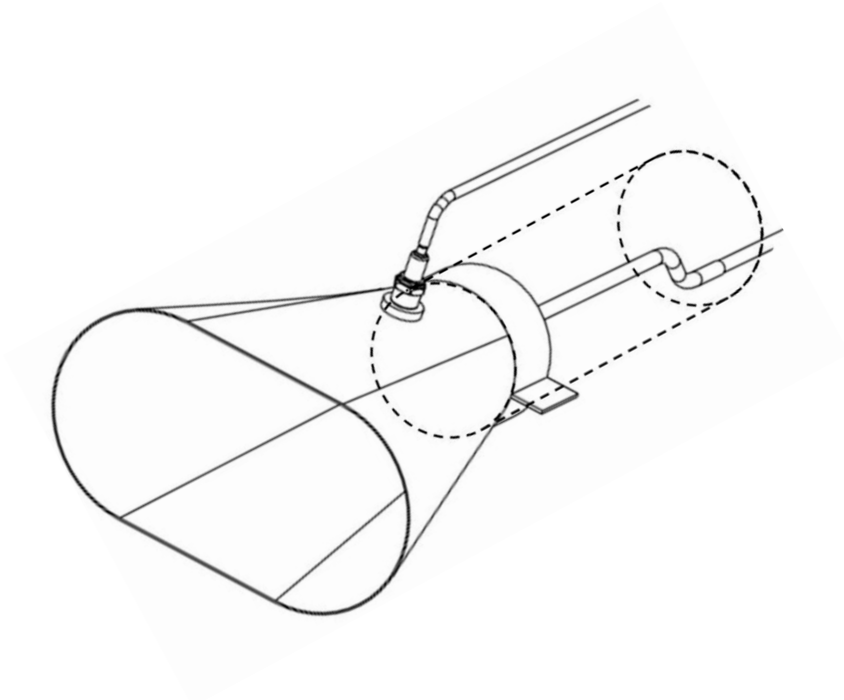


Figure A5-10. Proper routing of the spark plug wire

A5.5.4.5 Volumetric Airflow Control

The volumetric airflow is controlled via a regulated sonic nozzle. Adjust the upstream supply air pressure to 65 lb/in^2 ± 2 lb/in^2 (0.45 ± 0.014 MPa). The intake air temperature must be maintained within the range of 40°F to 60°F (4°C to 16°C). For more details, refer to appendix K, section K.3.2, Combustion Airflow Control.

A5.5.4.6 Fuel-Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon tubing and an appropriately sized graduated cylinder. Slip the Tygon tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon tubing into a small bucket or other collection basin. Turn on the fuel solenoid, making sure the ignition system is off. After establishing a steady stream of fuel flow, simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Do not disturb or move the tube while collecting fuel in the graduated cylinder. Collect the fuel for a 2-minute period, making certain to immediately remove the graduated cylinder from the fuel stream at precisely 2 minutes. Calculate the flow rate and ensure that it is 6.0 ± 0.2 gal/hr (22.68 L/hr ± 0.756 L/hr). If the flow rate is not within tolerance, adjust the fuel pressure accordingly. Record the fuel pressure necessary to achieve the required fuel flow. The recorded fuel pressure must be monitored and maintained during burner operation and fluctuate no more than ± 2 lb/in^2 (± 0.0138 MPa) during flame-consistency validation and sample testing. A flame-temperature validation or sample test will be void should the fuel pressure fluctuate outside of this range during either procedure. The temperature of the fuel must be maintained within the range of 32°F to 52°F (0°C –11°C).

NOTE: When collecting fuel during the fuel-flow calibration check, it is important to establish a steady stream of fuel before starting the measurement process. The tube may need to fill with fuel directly above the fuel nozzle before a steady stream of fuel will flow freely from the tube end because of the inclined orientation of the insulation test burner. It is recommended the fuel flow steadily from the tube end for a minimum 10-second period before collecting fuel in the graduated cylinder.

A5.6 Burner Flame Consistency Validation

A5.6.1 Sonic Burner

The sonic burner used in the test must be checked to ensure the proper flame temperature is being produced for consistent and accurate test results.

A5.6.1.1 Move the test-sample apparatus from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of combustion products, such as soot. Soot buildup inside the cone may affect the flame characteristics and cause flame temperature validation difficulties. Check to ensure the burner cone dimensions are within specified tolerances before flame validation.

A5.6.1.2 Mount the thermocouple rake on a movable stand that is capable of being quickly translated into position in front of the burner. Move the rake into the flame-validation position and check the distance of each of the seven thermocouples to ensure that they are located 4 ± 0.125 inches (102 ± 3 mm) from the vertical plane of the burner cone exit. Ensure that the horizontal centerline of the thermocouples is offset 1 ± 0.063 inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone (see figure A5-4). Place the center thermocouple (thermocouple number 4) in front of the center of the burner cone exit. Note that the movable thermocouple rake stand must incorporate detents that ensure proper centering of the thermocouple rake with respect to the burner cone so that rapid positioning of the rake can be achieved during the validation procedure. Once the proper position is established, move the thermocouple rake away, and move back into the flame-temperature validation position to recheck distances. When all distances and positions are confirmed, move the thermocouple rake away from the burner.

A5.6.1.3 While the thermocouple rake is away from the burner, turn on the spark plug, pressurized air, and fuel flow; light the burner. Allow burner to warm up for 2 minutes. After warmup, move the thermocouple rake into position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for 30 seconds. Remove the thermocouple rake from the flame-temperature validation position and turn off the burner. Calculate the average temperature of each thermocouple over this period and record. Although not a requirement for testing, the recommended average temperature of each of the seven thermocouples should be 1900°F ± 100°F (1038°C ± 55°C). The burner should be rechecked to ensure it is configured properly if temperatures are measured outside of this recommended range. A flame that appears biased to one side, or produces significantly higher temperatures on one end of the flame validation thermocouple rake, may indicate that an adjustment of the fuel nozzle, internal stator orientation, or distance from the end of the draft tube may be necessary if the adjustments are within allowable tolerances. If no problems are found with the burner, any thermocouple reading outside of this range may require replacement. It is recommended that the burner flame temperature be validated at the beginning and end of each day testing is performed.

NOTE 1: The thermocouples are subjected to high temperature durations during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases or extreme variations in temperature or no temperature reading at all are signs that the thermocouple or thermocouples are degrading or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

NOTE 2: The sonic burner is sensitive to proper alignment of the fuel nozzle. It is crucial that the fuel nozzle be aligned to the geometric center of the turbulator. A slight adjustment of the fuel tube between the stator and fuel nozzle may be required to obtain an even temperature profile across the thermocouple rake. The center point of the nozzle where the fuel exits should not deviate more than 0.0625 inch from the geometric center of the turbulator exit plane when looking into the burner draft tube. This should be performed only after checking the burner for proper configuration.

A5.7 Test Procedure

A5.7.1 Secure the two insulation blanket test samples to the test frame. The insulation blankets should be attached to the test rig's center vertical former using four spring clamps positioned as shown in figure A5-6 (according to the criteria of paragraph A5.4.4 of this chapter).

A5.7.2 Ensure that the vertical plane of the burner cone is at a distance of 4 ± 0.125 inches (102 ±3 mm) from the outer surface of the horizontal stringers of the test-sample frame, and that the burner and test frame are both situated at a 30° angle with respect to vertical.

A5.7.3 When ready to begin the test, move the test samples away from the burner test position to the warmup position so that the flame will not impinge on the samples prematurely. Turn on and light the burner, and allow it to stabilize for 2 minutes.

A5.7.4 To begin the test, move the test frame containing the insulation samples into the test position in front of the burner, and simultaneously start the timing device.

A5.7.5 Expose the test samples to the burner flame for 4 minutes, and then turn off the burner. Immediately move the test-sample frame out of the test position away from the burner.

A5.7.6 Determine (if applicable) the burnthrough time or the point at which the heat flux exceeds 2.0 Btu/ft^2-sec (2.27 W/cm^2) on either of the two HFGs.

A5.8 Report

A5.8.1 Identify and describe the sample being tested.

A5.8.2 Report the number of insulation blanket samples tested.

A5.8.3 Report the burnthrough time (if any) and the maximum heat flux on the back face of the insulation blanket test sample, and the time at which the maximum occurred.

A5.9 Requirements

A5.9.1 Each of the three sets of insulation blanket test samples must not allow fire or flame penetration in less than 4 minutes.

A5.9.2 Each of the three sets of insulation blanket test samples must not allow more than 2.0 Btu/ft^2-sec (2.27 W/cm^2) on the cold side of the insulation samples at a point 12 inches (30.5 cm) from the face of the test rig.

A5.9.3 If one or more sample sets fails to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of sample sets meet the requirements. For example, if one of the three original sample sets fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experience an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Chapter A6
Oil Burner Flammability Test for Magnesium Alloy Seat Structure

A6.1 Scope

A6.1.1 Applicability

This test method evaluates the ignition resistance and flammability of magnesium alloy when used in the construction of aircraft seat primary structural components by using a high-intensity open flame to show the material adequately resists involvement in a post-crash fire.

A6.2 Definitions

A6.2.1 Magnesium Alloy

A magnesium alloy is defined as any solid form of magnesium containing a variety of alloying materials (e.g., zinc) or rare-earth elements (e.g., yttrium). Any component or material containing more than 10 percent elemental magnesium by weight shall be considered a magnesium alloy.

A6.2.2 Sample Set

A sample set consists of three or more replicate test samples of a particular magnesium alloy used in the construction of an aircraft seat primary load path structural component.

A6.2.3 Melting

Melting is defined as the point at which the sample becomes elastic enough that a significant portion of the sample breaks free and falls into the catch pan. Bending, warping, or sagging alone does not constitute melting.

A6.2.4 Ignition

Ignition is defined as the first observation of sparking of the magnesium alloy sample when subjected to the burner flames. The point of ignition is typically a very bright, intense, blue-white flame that can be differentiated from the surrounding yellow-orange flames being produced by the oil burner. Ignition is often the precursor to burning, in which the material experiences sustained ignition.

A6.2.5 Burning

Burning (sustained ignition) is defined as an ignition lasting for 10 consecutive seconds (i.e., the start time of an ignition lasting for more than 10 seconds shall be considered the beginning of the burning period in the event that ignition stops and then restarts).

A6.2.5 Weight Loss

The sample weight loss is the amount of weight a sample loses during exposure to the burner flames, which includes any portion of the test sample that melts and falls into the catch pan.

Molten pieces of the test sample must be retrieved from the catch pan following test completion once sufficient cooling has taken place. Molten/resolidified pieces of the test sample must be blown off with compressed air to eliminate the inclusion of oxidized material or talc during the final weight measurement. The percentage weight loss for a sample is defined as the pretest weight of the sample less the posttest weight of the sample and any droppings, expressed as the percentage of the pretest weight.

A6.3 Apparatus

A6.3.1 Test-sample Apparatus

The test-sample apparatus is shown in figures A6-1 and A6-2. The test-sample apparatus must allow movement of the test sample so it can be positioned in front of the burner at the proper distance. It is recommended that the apparatus allow for a minimum of 36 inches of distance between the burner cone and sample during burner warmup to prevent preheating of the sample.

A6.3.1.1 Catch Pan

The test-sample apparatus must include a suitable catch pan lined with a layer of dry talc powder, capable of preventing backsplash of molten magnesium alloy. The talc should be filled to a depth of 0.25 inches (6 mm), as measured from the highest point on the base of the catch pan. The catch pan should measure at least 8 inches (200 mm) wide by 16 inches (410 mm) long and at least 1.5 inches (38 mm) deep. A test-sample holder can be mounted directly to the sides of the catch pan.

A6.3.1.2 Talc

Talc is a magnesium-silicate-based mineral. Talc should be kept dry between test runs and renewed as appropriate. Storage in a sealed plastic bag is recommended to avoid moisture pickup.

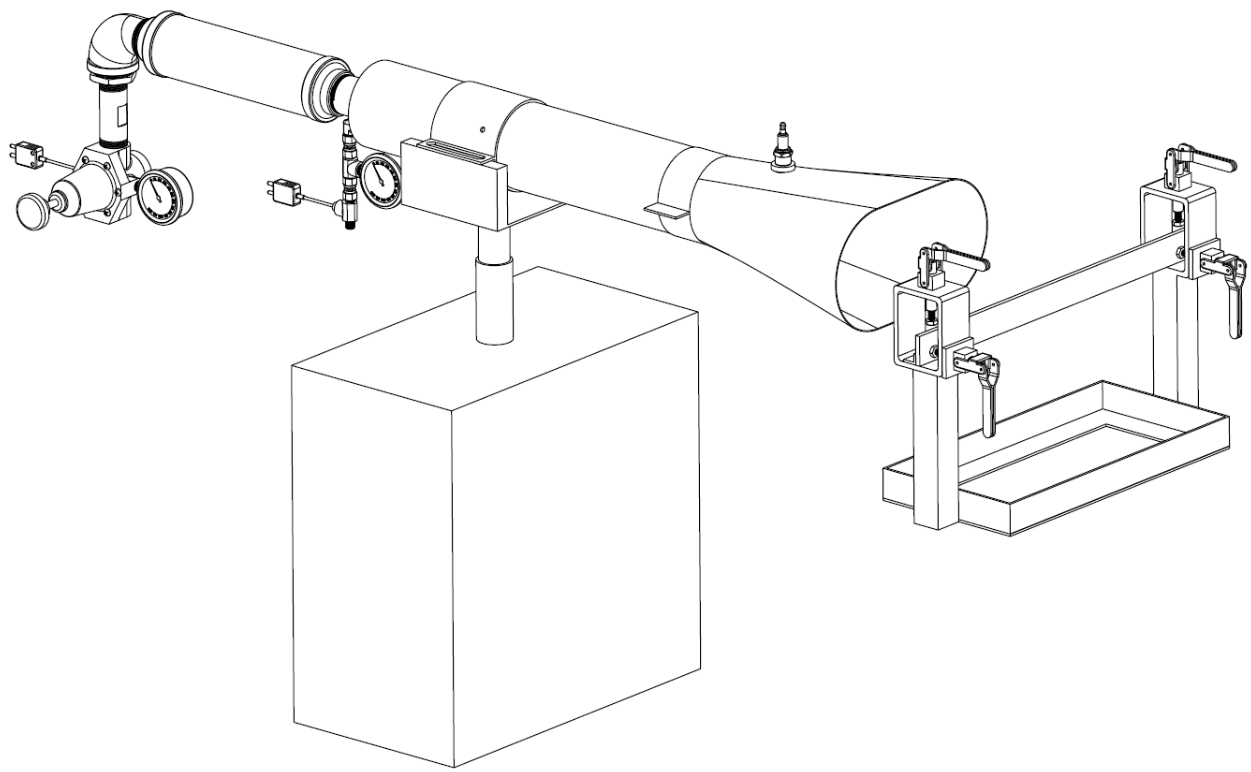


Figure A6-1. Magnesium alloy testing apparatus

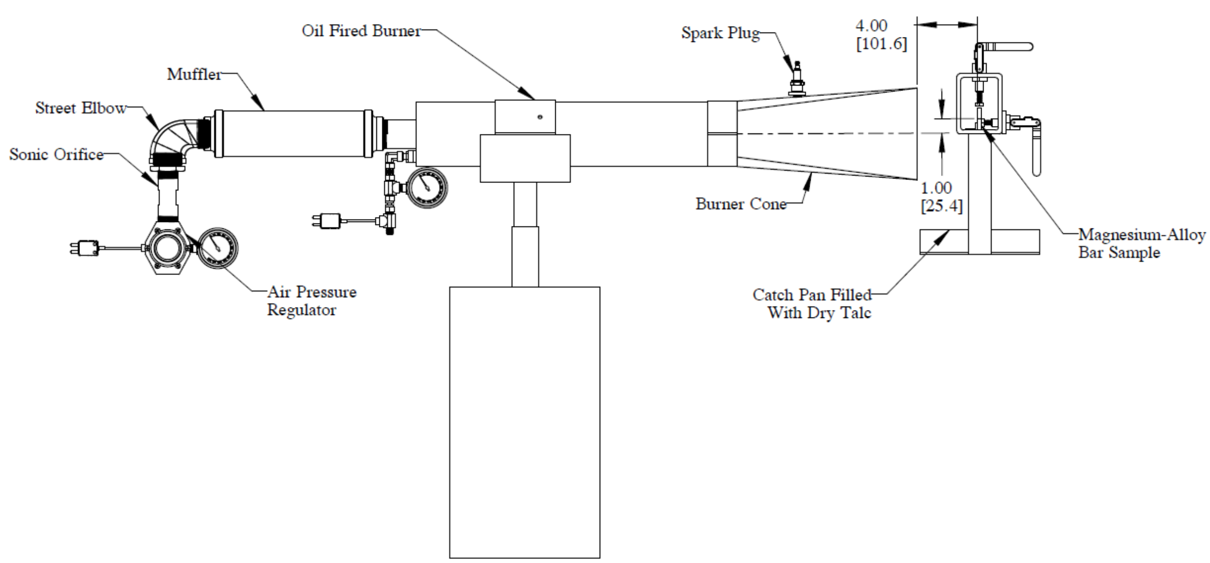


Figure A6-2. Magnesium alloy testing apparatus

A6.3.1.3 Test-sample Stand and Holder

A test-sample mounting stand and holder must be used to rigidly mount the horizontal bar sample in the proper position with respect to the test burner (see figure A6-3). A suitable sample holder can be fabricated using 2-inch (51 mm) lengths of 3- by 4- by 0.250-inch-thick (76- by 102- by 6-mm) steel box tubing. Two sections of box tubing can be mounted on top of 1.5-inch by 1.5-inch (38- by 38-mm) box tubing uprights that are welded to the sides of the catch pan. The rectangular cross section sample holder segments can be drilled for insertion of push-/pull-style toggle clamps that hold the sample in the proper position (see figure A6-4). The toggle clamps should have adjustable plungers to allow the proper amount of pressure against the sample.

NOTE: Push/pull-toggle clamps manufactured by Carr Lane (www.carrlane.com), part number CL-250-TPC, have been found suitable for this application.

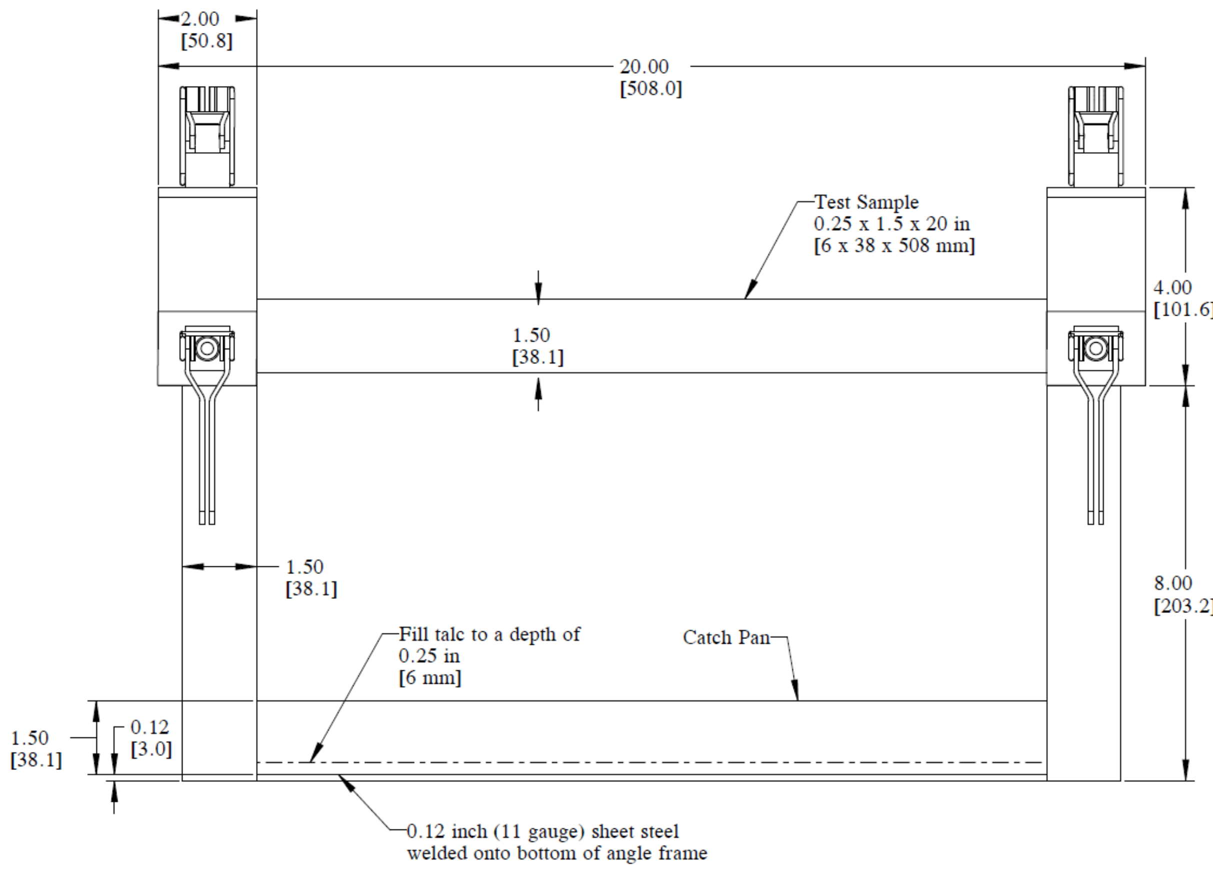


Figure A6-3. Magnesium alloy test-sample mounting stand and holder (front)

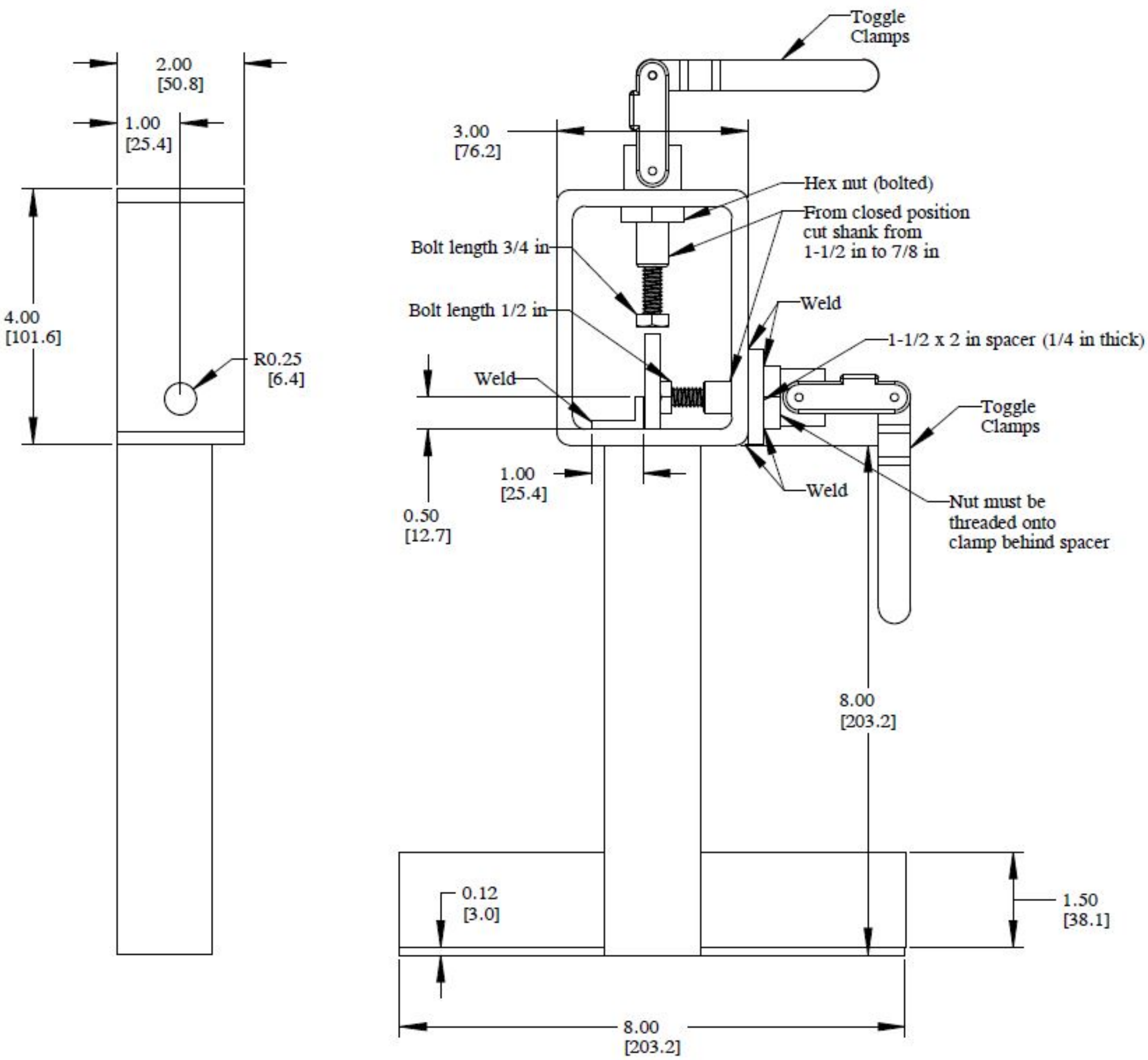


Figure A6-4. Magnesium alloy test-sample mounting stand and holder (side)

A6.3.2 Test Burner

The test burner is the Sonic Fire Test Burner, described in detail in appendix K. The burner configuration for this test method is displayed in table A6-1.

Table A6-1. Burner configuration for the magnesium alloy flammability test

Fuel	Nozzle	2.0 gal/hr 80° Solid Spray
	Volumetric Flow Rate (gal/hr)	2.0 ± 0.1
	Pressure (psi)	110 ± 10
Air	Diffusion Method	Stator and Turbulator
	Pressure (psig)	45 ± 1
	Mass Flow Rate (SCFM)	54.2
	Burner Orientation	Horizontal

A6.3.2.1 Inlet Condition Measuring

To obtain an accurate measurement of the conditions entering the burner, the fuel pressure and temperature, and air pressure and temperature measurements must be made nearest to the burner inlet (see figure A6-5). To minimize air stream disruptions, the intake air temperature must be measured prior to the sonic nozzle.

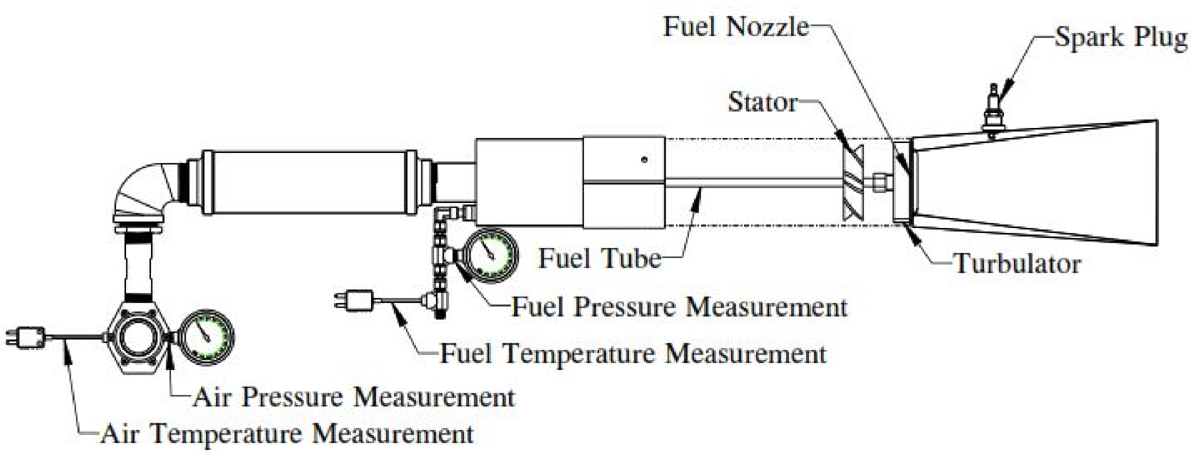


Figure A6-5. Inlet condition measurement location (side view)

A6.3.2.2 Fuel Nozzle

A screw-in fuel nozzle is required to maintain a fuel pressure that will yield a 2 ± 0.1 gal/hr (7.57 L/hr ± 0.38 L/hr) fuel flow. A nozzle with an 80° solid spray angle nominally rated at 2.0 gal/hr (7.57 L/hr) at 100 lb/in^2 (0.69 MPa) has been found to deliver the appropriate flow rate and produce the proper flame pattern. Actual flow-rate measurements may deviate from the advertised flow rate. The actual flow rate must be measured manually using a flexible tube, graduated cylinder, and timing device, as described in section A6.5.4.6. The fuel pressure must then be adjusted accordingly to produce the required fuel flow of 2 ± 0.1 gal/hr (7.57 L/hr ± 0.38 L/hr). For more details, refer to appendix K, section K.3.4.4, Fuel Nozzle.

A6.3.2.3 Fuel Pressure Regulation

The fuel must be properly pressurized to deliver the proper fuel flow. Ideally, this pressure must be in the range of 100–120 lb/in^2 (0.69 to 0.83 MPa). For details on fuel pressurization and regulation, refer to appendix K, section K.3.4, Fuel System.

A6.3.2.4 Fuel Type

A kerosene-type fuel is used in the burner equipment. Jet A and JP-8 (military equivalent to Jet A) fuel is recommended; however, other fuels are permissible if the flame temperature can be maintained according to section A6.6.1.3. For more details, refer to appendix K, section K.3.4.6, Fuel.

A6.3.2.5 Burner Cone

A 12 ± 0.125-inch (305 ± 3-mm) burner extension cone is fitted to the end of the burner draft tube. The opening must be 6 ± 0.125 inches (152 ± 3 mm) high and 11 ± 0.125 inches (280 ± 3 mm) wide. For more details, refer to appendix K, section K.3.7, Burner Cone.

A6.3.2.6 Spark Plug

An automotive-style spark plug is fitted into a threaded boss, which is welded to the burner extension cone. The threaded boss is centered on the upper surface of the burner cone at a distance of 6 ± 0.125 inches (152 ± 3 mm) from the intake end of the burner cone. For more details, refer to appendix K, section K.3.5, Ignition System.

A6.3.3 Burner Flame Consistency Validation Thermocouples

Seven thermocouples must be used to check the flame temperature of the burner. The thermocouples must be 0.125-inch (3.2-mm) diameter, insulation packed, 310 stainless-steel sheathed, type K (chromel-alumel), grounded junction with a nominal 24 American Wire Gauge (AWG) size conductor. Thermocouples purchased with a certificate of calibration may provide more accurate readings but are not required. The seven thermocouples must be attached to a steel mounting plate to form a thermocouple rake for placement in front of the burner cone during the burner-flame consistency-validation procedure (see figure A6-6). It is recommended the thermocouple mounting plate be a minimum of 4 inches (102 mm) away from the tips of the thermocouples.

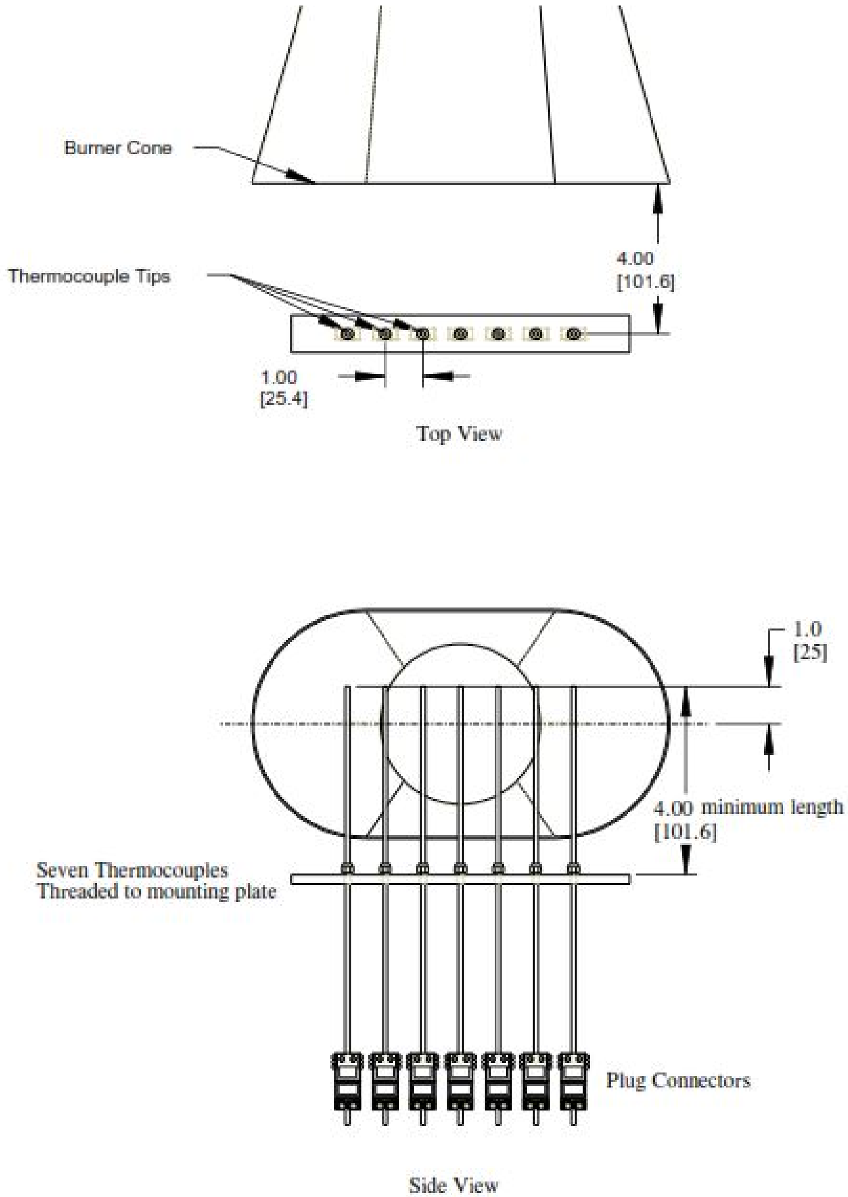


Figure A6-6. Top and side view of thermocouple rake bracket

A6.3.4 Instrumentation and Supporting Equipment

A6.3.4.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the outputs of the thermocouples.

A6.3.4.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame and the test-sample ignition and extinguishment times.

A6.3.4.3 Test Chamber Anemometer

A handheld vane-type or hotwire-type air velocity sensing unit capable of measuring accurately in the 0–100 ft/min range must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating. Airflow measurements should be taken at the beginning of the day prior to operating the test burner. A suitable hotwire anemometer, which may be mounted to the sample test frame, is manufactured by Dwyer Instruments, model number 641-6-LED. A suitable handheld hotwire anemometer is manufactured by TSI, model number 9515. Vane-type anemometers typically do not function properly with airflow rates of less than 50 ft/min.

A6.3.4.4 Digital Weight Scale

A suitable weight scale must be used to determine the initial and final weights of the test sample and the weight of any molten/resolidified portions of the test sample captured in the catch pan. The scale must have a resolution of 0.02 pounds (0.01 kg) and an accuracy of ±0.02 pounds (±0.01kg).

A6.3.4.5 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. Although not required, the recommended minimum of the test-chamber floor area is 15 feet by 15 feet (4.57 m by 4.57 m) or larger.

NOTE: Smaller test cells may experience significant increases in ambient air temperature while testing. This may increase the severity of the test.

A6.3.4.6 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

A6.4 Test Samples

A6.4.1 Sample Configuration

Test samples representing the primary seat frame components (e.g., leg, spreader, cross-tube, seat back frame, and lower baggage bar) must be constructed of the identical magnesium-alloy material to be used in service.

A6.4.2 Sample Number

A minimum of three samples for each magnesium alloy type or design configuration must be prepared for testing. These samples must exclude any surface modifications, such as intumescent paints or coatings, or any anodizing processes.

A6.4.3 Sample Size

The samples to be tested must measure 0.25 ±0.0063 inches (6.4 ±0.16 mm) thick by 1.5 ± 0.03 inches (38.1 ±0.8 mm) in height by 20 ±0.06 inches (508 ±1.6 mm) in length. Test samples must be constructed according to the dimensions shown in figure A6-7.

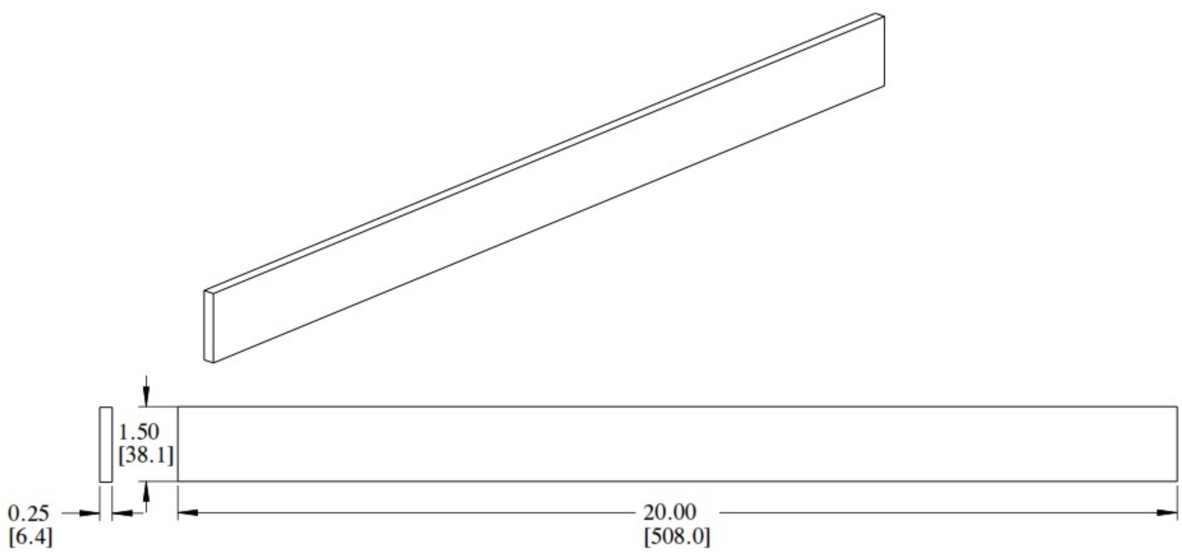


Figure A6-7. Test-sample dimensions

A6.4.4 Sample Orientation

The samples are mounted horizontally, with the midpoint of the sample's face located 4 inches (102 mm) from the vertical exit plane of the burner cone and 1 inch (25 mm) above the burner centerline (refer to figure A6-2).

A6.4.5 Sample Finish

A machined surface finish to all faces is required for the test samples (e.g., an average roughness value Ra of less than 1.75 µm and typically 0.9 µm).

A6.4.6 Sample Coatings

If a finish coating, anodizing, or other standard aerospace grade surface treatment is used on the alloy in service, it is sufficient to test the coated materials using the 12-second vertical Bunsen burner test method described in Chapter A1 of this handbook (Vertical Bunsen Burner

Test for Cabin and Cargo Compartment Materials). Vertical Bunsen burner test samples must be fabricated with the coating applied to the magnesium alloy substrate that it will be used on in service, using the production process. The test must be conducted using a substrate thickness representative of the thinnest cross section of the in-service component. If the coating/substrate passes in this thickness (critical test configuration), the coating can be applied to any thicker in-service components of the identical magnesium alloy material without additional testing. Any in-service components having thinner cross sections will require additional vertical Bunsen burner substantiation using that coating/substrate thickness.

A6.4.7 Sample Conditioning

The samples must be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

A6.5 Preparation of Apparatus

A6.5.1 Alignment

Mount a test sample on the test-sample frame. Level and center the sample-holder frame assembly to ensure alignment with the burner cone. Move the test-sample mounting frame into position in front of the burner, and check for proper alignment (i.e., distance from exit of burner cone to face of test sample, proper sample height with respect to cone centerline). The movable assembly should incorporate mechanical stops or detents to ensure that the samples can be moved into position quickly without measurement during testing.

A6.5.2 Chamber Ventilation

Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. With the sample still in the test fixture, measure the airflow in the test chamber using a hotwire anemometer or equivalent measuring device. The vertical air velocity within a 12-inch (30.5 cm) radius from any point on the horizontally positioned sample must be less than 100 ft/min (50.8 cm/sec). The horizontal air velocity within a 12-inch (30.5 cm) radius from any point on the sample must be less than 50 ft/min (25.4 cm/sec).

NOTE 1: Airflow measurements do not have to be taken for each sample tested. It is recommended the airflow measurements be taken at the beginning of the day before testing and at the end of the day when testing is completed.

NOTE 2: Personnel present within the test cell may influence air-velocity readings. This may be avoided by mounting the anemometer instrumentation to the sample holder during test cell air velocity measurements.

A6.5.3 Test Chamber Air Temperature

The temperature of the test chamber should be between 50°F and 100°F (10°C and 38°C) before the start of each test. The chamber air temperature should be measured at the same height as the center of the test sample, within 12 inches (30.5 cm) laterally. Remove the sample from the test frame. Do not use this sample for testing. The sample may be kept for future test-chamber airflow and temperature measurements.

A6.5.4 Sonic Burner Configuration

A6.5.4.1 Fuel Nozzle Location

The tip of the fuel nozzle, or fuel exit plane, must be located 0.1875 ± 0.020 inches (4.763 ± 0.5 mm) from the exit plane of the turbulator (see figure A6-8).

A6.5.4.2 Stator Adjustment

The stator is positioned by adjusting its translational position and its axial position on the fuel rod.

A6.5.4.2.1 Stator Translational Position

The front face of the stator must be located 2.6875 ± 0.020 inches (68.263 ± 0.5 mm) from the exit plane of the turbulator (see figure A6-8). This stator translational position is also 2.5 inches (63.5 mm) from the tip of the fuel nozzle.

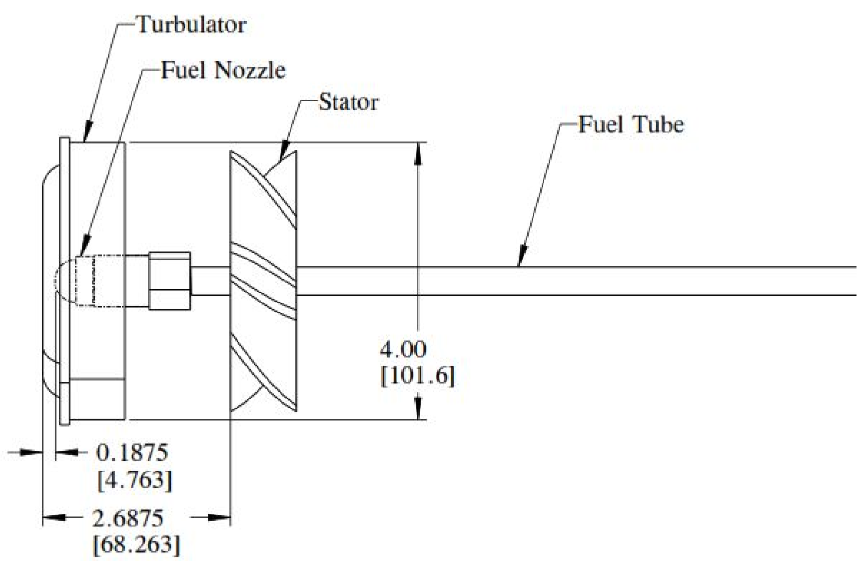


Figure A6-8. Fuel nozzle and stator locations

A6.5.4.2.2 Stator Axial Position

The line running through the set screw and geometric center of the stator will be used as a reference for properly orienting the rotational position of the stator. The stator must be positioned so the reference line angle is 0 degrees (12 o'clock) from the zero position when looking into the burner draft tube (see figure A6-9).

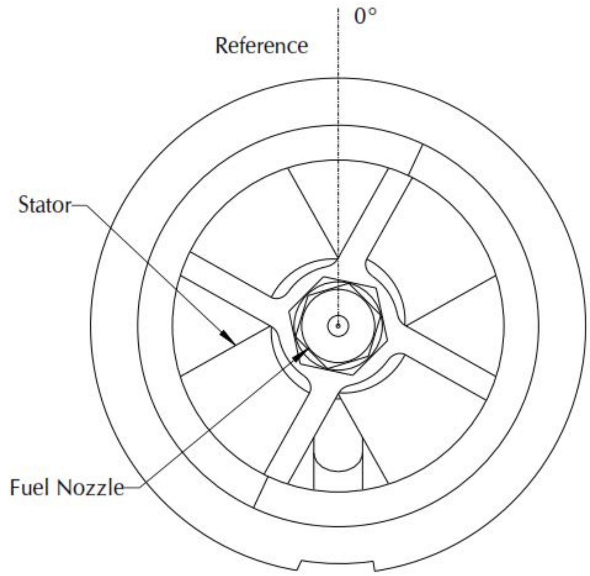


Figure A6-9. Stator axial position

A6.5.4.3 Spark Plug

A high-voltage oil burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone.

A6.5.4.3.2 Spark Plug Gap

The spark plug gap (distance) between the two electrodes must be 0.100 inch (2.5 mm), as shown in figure A6-10.

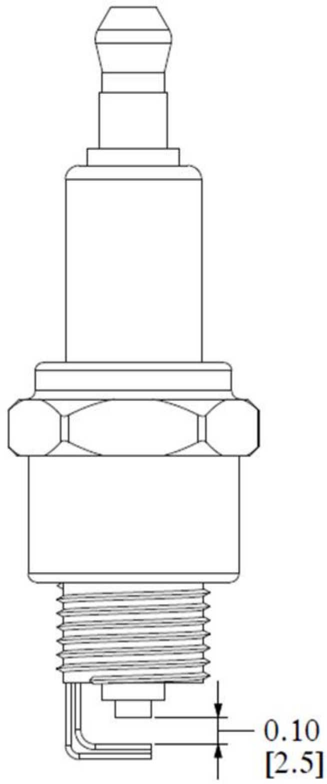


Figure A6-10. Spark plug gap measurement

A6.5.4.4 Spark Plug Wire Routing

The length and arrangement of the spark plug wire must be monitored to prevent heat damage during flame temperature validation and testing. Once the burner is ignited, the outside surface temperature of the burner cone will increase rapidly, becoming capable of damaging the wire if it comes in contact with the cone. The spark plug wire should be carefully routed to prevent contact with the cone or other hot surfaces, and should also be shielded in a heat-resistant covering to further protect it from convective heat damage from the burner flames. The wire can be routed as shown in figure A6-11, such that it does not contact any components in the vicinity of the burner cone.

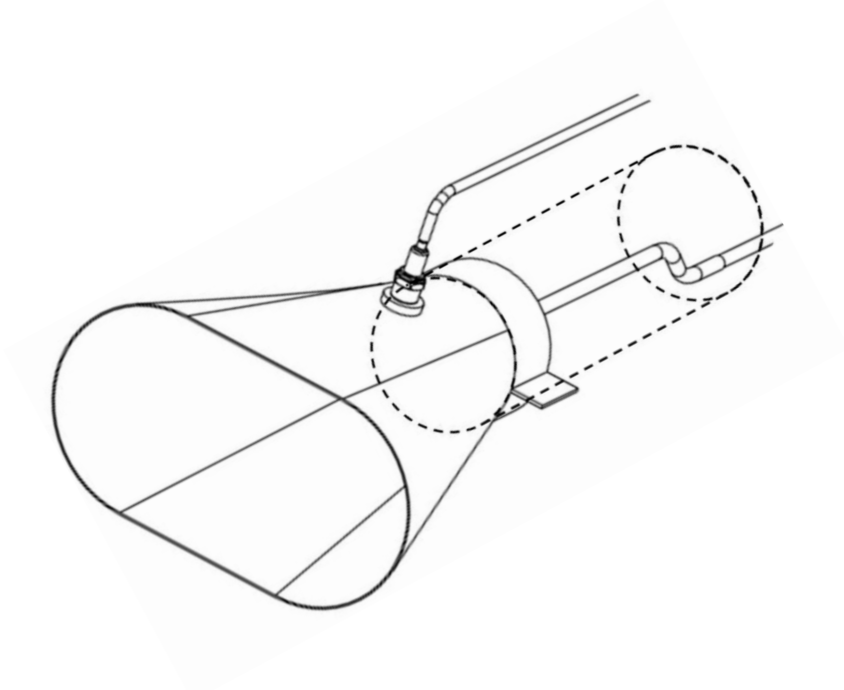


Figure A6-11. Proper routing of the spark plug wire

A6.5.4.5 Volumetric Airflow Control

The volumetric airflow is controlled via a regulated sonic nozzle. Adjust the upstream supply air pressure to 45 ± 1 lb/in^2 (0.31 ± 0.007 MPa). The intake air temperature must be maintained within the range of 40°F to 60°F (4°C to 16°C). For more details, refer to appendix K, section K.3.2, Combustion Airflow Control.

A6.5.4.6 Fuel Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon tubing and an appropriately-sized graduated cylinder. Slip the Tygon tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon tubing into a small bucket or other collection basin. Turn on the fuel solenoid, making sure the ignition system is off. After establishing a steady stream of fuel flow, simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Do not disturb or move the tube while collecting fuel in the graduated cylinder. Collect the fuel for a 2-minute period, making certain to immediately remove the graduated cylinder from the fuel stream at precisely 2 minutes. Calculate the flow rate and ensure that it is 2 ± 0.1 gal/hr (7.57 ± 0.38 L/hr). If the flow rate is not within the tolerance, adjust the fuel pressure accordingly. Record the fuel pressure necessary to achieve the required fuel flow. The recorded fuel pressure must be monitored and maintained during burner operation and fluctuate no more than ± 2 lb/in^2 (± 0.0138 MPa) during flame consistency validation and sample testing. A flame temperature validation or sample test will be void should the fuel pressure fluctuate outside of this range during either procedure. The temperature of the fuel must be maintained within the range of 32°F to 52°F (0°C –11°C).

NOTE: It is important to establish a steady stream of fuel before starting the fuel-flow measurement process. It is recommended that the fuel flow steadily from the hose for a minimum 10-second period before collecting fuel in the graduated cylinder.

A6.6 Burner Flame Consistency Validation

A6.6.1 Sonic Burner

The sonic burner used in the test must be checked to ensure the proper flame temperature is being produced for consistent and accurate test results.

A6.6.1.1 Move the apparatus from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of combustion products such as soot. Soot buildup inside the cone may affect the flame characteristics and cause flame-temperature validation difficulties. Check to ensure the burner cone dimensions are within specified tolerances before flame validation.

A6.6.1.2 Mount the thermocouple rake on a movable stand that is capable of being quickly translated into position in front of the burner. Move the rake into flame temperature validation position and check the distance of each of the seven thermocouples to ensure that they are located 4 ± 0.125 inches (102 ± 3 mm) from the vertical plane of the burner cone exit. Ensure that the horizontal centerline of the thermocouples is offset 1 ± 0.063 inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone (see figure A6-6). Place the center thermocouple (thermocouple number 4) in front of the center of the burner cone exit. Note that the movable thermocouple rake stand must incorporate detents that ensure proper centering of the thermocouple rake with respect to the burner cone so that rapid positioning of the rake can be achieved during the validation procedure. Once the proper position is established, move the thermocouple rake away and move back into the temperature-validation position to recheck distances. When all distances and positions are confirmed, move the thermocouple rake away from the burner.

A6.6.1.3 While the thermocouple rake is away from the burner, turn on the spark plug, pressurized air, and fuel flow; light the burner. Allow burner to warm up for 2 minutes. After warmup, move the thermocouple rake into position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for 30 seconds. Remove thermocouple rake from the flame-temperature validation position and turn off the burner. Calculate the average temperature of each thermocouple over this period and record. Although not a requirement for testing, the recommended average temperature for each of the seven thermocouples should be 1700°F ± 100°F (927°C ± 55°C). The burner should be rechecked to ensure it is configured properly if temperatures are measured outside of this recommended range. A flame that appears biased to one side, or produces significantly higher temperatures on one end of the flame validation thermocouple rake, may indicate that an adjustment of the fuel nozzle/internal stator orientation/distance from the end of the draft tube may be necessary if the adjustments are within allowable tolerances. If no problems are found with the burner, any thermocouple reading outside of this range may require replacement. It is recommended that the burner flame temperature be validated at the beginning and end of each day testing is performed.

NOTE 1: The thermocouples are subjected to high temperature durations during calibration. Because of this type of cycling, the thermocouples may degrade with use. Small but continuing decreases or extreme variations in temperature or no temperature reading at all are signs that the thermocouple or thermocouples are degrading, or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

NOTE 2: The sonic burner is sensitive to proper alignment of the fuel nozzle. It is crucial that the fuel nozzle be aligned to the geometric center of the turbulator. A slight adjustment of the fuel tube between the stator and fuel nozzle may be required to obtain an even temperature profile across the thermocouple rake. The center point of the nozzle where the fuel exits should not deviate more than 0.0625 inch from the geometric center of the turbulator exit plane when looking into the burner draft tube. This should be performed only after checking the burner for proper configuration.

A6.7 Test Procedure

A6.7.1 Examine and clean the cone of soot deposits and debris.

A6.7.2 Weigh the magnesium alloy test sample and record this initial weight.

A6.7.3 Mount the magnesium alloy test sample in the test frame sample holder. Verify that the horizontal test sample is level and that the center of the face of the sample being exposed is at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the vertical exit plane of the burner cone. Ensure that the horizontal centerline of the test sample is offset 1 ± 0.063 inch (25.4 ± 2 mm) above the horizontal centerline of the burner cone (see figure A6-2).

A6.7.4 Move the test frame assembly away from the burner to the standby position so that the flame does not impinge on the test sample during the warmup period. The shortest measured distance between the burner cone and the test sample should be 18 inches (460 mm) or greater when in the warmup position. Turn on the burner and allow it to stabilize for 2 minutes.

A6.7.5 Move the test frame assembly into the test position, and simultaneously start the timing device when the test frame is fully in the test position.

A6.7.6 Record the time for the sample to melt and the time of burning (sustained ignition) of the sample.[1]

[1] Burning (sustained ignition) is defined as an ignition lasting for 10 consecutive seconds (i.e., an ignition lasting for more than 10 seconds shall be considered the beginning of sample burning, in the event that ignition stops and then re-starts).

A6.7.7 Expose the test sample to the flames for 4 minutes, then slowly move the test frame assembly away from the burner to the standby position, and turn off the burner.

A6.7.8 Continue to observe the test sample remaining in the sample holder after removal from the test position. If the sample is still burning, measure the time when the burning ends.

A6.7.9 When the test sample has cooled sufficiently, loosen the toggle clamps and remove the sample. Record the final weight. Also remove any sample remnants located in the catch pan, and record these weights after first removing any residual oxidation and talc powder.[2]

To expedite the sample mounting and testing process, several sample holder/catch pans can be incorporated. The catch pan can use pins or other quick-release mechanisms to facilitate rapid removal following each test. Once the test is complete, the entire sample holder and catch pan, including talc and sample remnants, can be removed from the testing area and replaced with a new sample holder, catch pan, and test sample. Ensure that the new test sample is properly aligned with the burner.

A6.8 Report

A6.8.1 Report a complete description of the material(s) being tested, including manufacturer, alloy content, and trade name.

A6.8.2 For each of the three samples, report the time for the sample to melt (visual observation when sample center section separates from remaining test sample). Also report the time of burning (sustained ignition) and the time when the sample self-extinguishes.

NOTE: Measuring the exact time of flame (self) extinguishment of the test sample is difficult and subjective, given the nature of a burning magnesium alloy. The transition of the alloy from burning to self-extinguishment typically happens gradually rather than instantaneously, as is the case with most traditional cellulosic materials. For this reason, a maximum allowable time until self-extinguishment of the test sample is not required. However, if new magnesium alloys become available that exhibit extended burn periods prior to self-extinguishment but still pass the weight loss criteria, it may be necessary to incorporate a maximum time requirement for the alloy to self-extinguish.

A6.8.3 Calculate and record the weight percentage loss of each test sample by combining the final weight of the sample remaining in the holder and any additional remnants removed from the catch pan. Ensure that the remnant weight includes only metallic components and no oxidized material or talc. The combined weight of the tested sample and remnants can be subtracted from the initial weight of the sample. This value can then be divided by the initial weight and the value multiplied by 100 to determine the percentage weight loss.

[2] Residual oxidation and talc powder can be removed from the sample and retrieved molten/resolidified pieces by blowing them off with compressed air. This process should be completed within 1 hour of the end of the test.

A6.8.4 Record any observations regarding the behavior of the test sample during flame exposure, such as popping, explosions, smoke, and the time each event occurred.

A6.8.5 Provide a record of burner flame consistency validation.

A6.9 Requirements

A6.9.1 None of the three samples tested may burn (sustained ignition) in less than 2 minutes of burner exposure.

A6.9.2 The calculated weight loss of each sample must not exceed 10 percent.

A6.9.3 If one or more samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

CHAPTER B: FLAMMABILITY TESTS BASED ON AN IN-FLIGHT FIRE THREAT

Chapter B1
Fire-Containment Test of Waste Stowage Compartments

B1.1 Scope

B1.1.1 These methods are intended for use in determining the fire-containment capability of containers, carts, and compartments used to store combustible waste materials according to the requirements of 14 CFR 25.853(e) through amendment 51.

B1.1.2 Parts construction used for the top, bottom, and sides of these compartments must meet the requirements of §§ 25.853 and 25.855. These tests are covered elsewhere in this handbook in Chapter A1, Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials; Chapter C1, 45-Degree Bunsen Burner Test for Cargo Compartment Liners and Waste Stowage Compartment Materials; and Chapter D2, 60-Degree Bunsen Burner Test for Electrical Wire.

B1.1.3 Multiple test arrangements are covered in this specification: entrée carts, meal carts, waste carts, and waste compartment meal boxes (see table B1-1 for meal boxes).

Table B1-1. Meal box test arrangements

Equipment Description	Meal Box Stowed in Open Galley Compartment	Enclosed Galley Compartment	Open Cart Compartment	Enclosed Cart Compartment
Metallic meal box, complete enclosure	No test required	No test required	Test meal box within trolley compartment	Test trolley
Metallic meal box, incomplete enclosure	Uncertifiable for waste storage	Test meal box within the compartment	Uncertifiable for waste storage	Test meal box within trolley compartment
Nonmetallic meal box, complete enclosure	Test meal box (unstowed)	Test meal box (unstowed)	Test meal box within trolley compartment	Test trolley compartment with and without meal box
Nonmetallic meal box, incomplete enclosure	Uncertifiable for waste storage	Test meal box/ compartment	Uncertifiable for waste storage	Test trolley compartment with and without meal box

B1.2 Definitions

B1.2.1 Air Ducting

Air ducting is used for conveying chilled air to and from carts.

B1.2.2 Waste Cart

An enclosure on wheels that provides a means of accumulating/storing waste.

B1.2.3 Meal Cart

An enclosure on wheels used to store food and used or unused service trays that might contain waste.

B1.2.4 Entrée Cart

An enclosure on wheels used to cook or store food at elevated temperatures and transport/store unused or used food service trays that might contain waste.

B1.2.5 Integral Floor

The bottom panel of a waste compartment.

B1.2.6 Waste Compartment (Galley or Lavatory Module)

An enclosure or shell structure with access provisions, such as a waste-chute opening or doors, designed for the purpose of accumulating or storing waste.

B1.2.7 Waste Container

A removable receptacle stored within a waste compartment or waste cart designed to accumulate or store waste within the compartment or cart.

B1.2.8 Meal Box

A removable enclosure located in a meal trolley or galley compartment used to store food and used or unused service trays that might contain waste.

B1.3 Test Apparatus/Equipment

B1.3.1 Thermocouple(s)

A thermocouple may be needed to monitor internal test unit temperature.

B1.3.1.1 If a thermocouple is used for meal or entrée carts, it will be installed 1.5 to 2 inches above the topmost tray. A second thermocouple will be placed on the bottom tray in a similar manner.

B1.3.1.2 For waste compartments/carts, a single thermocouple is inserted through the waste flap and placed 1.5 to 2 inches above the waste combustibles surface.

B1.3.2 Thermocouple Readout/Recording

If used, thermocouples will be connected to a system that is capable of providing continuous temperature readings. A recording system will be used so that temperatures can be recorded continuously or at intervals not exceeding 15 seconds.

B1.3.3 Galley

Galley structure is used to simulate the interface needed for the stowed cart test arrangements.

B1.3.3.1 The galley structure will be equipped with power outlets and air inlet/outlet ducting to circulate ambient air at the design-specified airflow to the cart when set up to conduct testing.

B1.3.4 Waste Materials

B1.3.4.1 Combustibles

B1.3.4.1.1 The meal cart arrangement includes the following combustibles:

- One set of plastic eating utensils
- One cup
- One salad dish
- One salad dressing container
- One entrée dish
- One dessert dish
- One crumpled 2-ply paper napkin, approximately 16 by 16 inches

The trays, each loaded with the above combustibles or equivalent representative materials found in service, will be inserted into the cart so that 75 percent of the trays are loaded in the cart starting from the bottom.

B1.3.4.1.2 For the entrée cart test arrangement, combustibles will consist of the same items per tray as for the meal cart for the stowed test. For fire source, the bottom tray will have an entrée dish half-filled with methyl alcohol to simulate grease. The napkin will not be located near the alcohol source. For the unstowed test, treat the entrée cart as a meal cart.

B1.3.4.1.3 For the waste compartment/waste cart, combustibles will be crumpled and will consist of the following proportions of materials or an equivalent:

- Eight 2-ply paper towels, approximately 10 by 11 inches (40 percent by number)
- Five 2-ply paper napkins, approximately 16 by 16 inches (25 percent by number)
- Four 8-ounce paper hot drink cups (20 percent by number)
- Two 3-ounce paper cold drink cups (10 percent by number)
- One empty cigarette package (5 percent by number)

The total amount of the above crumpled combustibles in the above proportions will be sufficient to fill the waste compartment or waste container to three-fourths capacity.

B1.4 Test Unit

B1.4.1 The unit to be tested will be equivalent to an actual production unit, built to drawing specifications and tolerances.

B1.4.2 A statement of conformity will be obtained for each test unit prior to testing.

B1.5 Test Arrangements

B1.5.1 Meal Cart Test Arrangements

B1.5.1.1 Unstowed Meal Cart

The unstowed meal-cart arrangement requires a condition in which the cart is tested in a freestanding position. Photographs (refer to section B1.7.3) will show the door with the chilled air duct interfaces (if applicable).

B1.5.1.2 Stowed Meal Cart

The stowed meal-cart test arrangement requires the cart be installed in the galley cart compartment with the air inlet/outlet openings connected to the air ducting. During the test, air is to be circulated through the cart at the design flow rate. To simulate the cart/galley interface, photographs of the meal cart should be taken from the side to show the cart vendor. The maximum cart/galley misalignment will be reproduced during the test.

B1.5.2 Waste Cart Arrangements

Testing both with and without the waste container is required if the waste container is nonmetallic. The waste cart interface with the galley (i.e., galley waste flap and waste chute) is also required to be simulated if the waste chute enters the cart enclosure or keeps the cart waste flap open.

B1.5.2.1 An unstowed waste-cart (waste container not installed) test arrangement requires a freestanding position at room temperature and still air. Photographs must be taken showing the cart door and flap.

B1.5.2.2 An unstowed waste-cart (waste container installed) test arrangement requires that the cart be in a freestanding position, per section B1.5.2.1, with the waste container installed.

B1.5.2.3 A stowed waste-cart (waste container not installed) test arrangement requires that the interface of the galley structure with the cart be simulated. The cart will be stowed in a galley mockup that completely simulates the galley/cart interface. Photographs will be taken that clearly show the waste chute/waste cart interface and the cart door during the test.

B1.5.2.4 The stowed waste cart (waste container installed) arrangement is equivalent to section B1.5.2.3, except that a waste container is installed.

B1.5.3 Entrée Cart Arrangement

B1.5.3.1 An unstowed entrée cart test arrangement requires that the cart be tested in a freestanding position at room temperature and still air.

B1.5.3.2 A stowed entrée-cart test arrangement requires that the cart be connected to the galley power and, if applicable, air ducting outlets. Power will be supplied to the cart for the duration of the test. All heaters and fans will be switched on with any timers set to the maximum duration. If the cart receives air from the galley ducting when the power is switched off, then a third test (stowed meal-cart test arrangement) is required.

B1.5.4 Waste Compartment Arrangements

B1.5.4.1 The only condition in which waste compartments without an integral bottom or base panel are to be tested is with the waste container installed within the waste compartment. If a liner is used within the waste container, the test will be conducted both with and without the liner installed. Ambient conditions will be room temperature and still air. Photographs will show the compartment door and the waste flap.

B1.5.4.2 Waste compartments may be tested without a waste container for waste compartments with an integral floor. If the waste container is nonmetallic, then a waste compartment with an integral floor must be tested both with and without the waste container installed. If a liner is used within the waste container, the test will be conducted both with and without the liner installed.

B1.5.5 Meal-Box Arrangements

The different types and arrangements of meal boxes that require testing are defined in table B1-1. Meal boxes are to be tested in the same manner as a meal cart (see section B1.6.1).

B1.6 Procedure

B1.6.1 Ignition

B1.6.1.1 Meal Cart

B1.6.1.1.1 Stowed Meal-Cart Test Arrangement

Ignite two crumpled 2-ply paper napkins, approximately 16 by 16 inches in size. Place them side by side adjacent to the combustibles, defined in section B1.3.4, already in place on the bottom tray at the greatest possible distance from the air inlet/outlet openings of the cart. Allow a good flame front to develop by allowing approximately 50 percent of the surface of the waste materials to ignite. Insert the tray into the cart, record the temperature, and close the door. Place the cart into the simulated galley structure so that it is connected with the galley duct/cart interface. The airflow through the cart will be at the design airflow rate.

B1.6.1.1.2 Unstowed Meal-Cart Test Arrangement

Ignite two crumpled 2-ply paper napkins, approximately 16 by 16 inches in size. Place them side-by-side adjacent to the other combustibles, defined in section B1.3.4, already on the bottom tray. Allow a good flame front to develop by allowing approximately 50 percent of the surface of the waste materials to ignite. Insert the tray into the cart, and simultaneously close the door and record the temperature if the temperature is being monitored.

B1.6.1.2 Entrée Cart

B1.6.1.2.1 Stowed Entrée Cart

Connect the entrée cart filled with the combustibles from section B1.3.4.1.2 to the power source, and energize all heaters and/or fans. Ignite the methyl alcohol in the entrée dish on the bottom tray by placing a burning napkin onto the tray. Insert the tray into the cart, close the cart door, and simultaneously record the temperature if the temperature is being monitored.

B1.6.1.2.2 Unstowed Entrée Cart

Proceed per the unstowed meal-cart test configuration of section B1.6.1.1.2.

B1.6.1.3 Waste Cart

B1.6.1.3.1 Stowed Waste Cart With Waste Container

Ignite a paper napkin and place it in the waste container through the waste flap. Allow a good flame front to develop by allowing 50 percent of the surface of the waste materials to ignite. Close the waste flap and simultaneously record the starting temperature.

B1.6.1.3.2 Stowed Waste Cart Without Waste Container

Proceed per section B1.6.1.3.1, except that no waste container is used.

B1.6.1.3.3 Unstowed Waste Cart With Waste Container

Proceed per section B1.6.1.3.1.

B1.6.1.3.4 Unstowed Waste Cart Without Waste Container

Proceed per section B1.6.1.3.2.

B1.6.1.4 For the waste compartment with and without waste container, proceed per applicable waste can arrangement, sections B1.6.1.3.1 and B1.6.1.3.2.

B1.6.1.5 For the meal box, proceed per section B1.6.1.1.

B1.6.2 Temperature

If the temperature is being monitored, it will rise rapidly, peak, and then fall below 150°F (66°C) as the flame dies out. The peak in temperature is necessary to identify that combustion has taken place. An example of this temperature peak is visualized in the temperature versus time plot shown in figure B1-1. When the temperature indicated by the thermocouple falls below 150°F (66°C), the test is terminated and the item examined for damage. If a suitable temperature peak above 150°F (66°C) is not obtained after three trials, sufficient ventilation will be provided to achieve a peak.

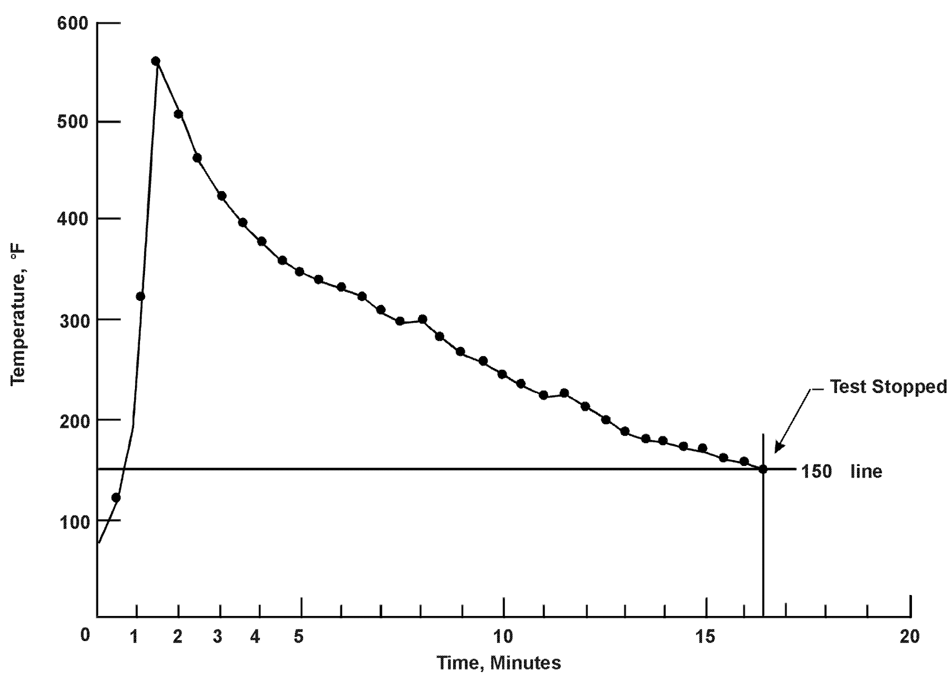


Figure B1-1. Sample fire-containment temperature versus time plot

B1.6.3 Photographs

Photographs, preferably in color, are required to document the progress of the test. Suggested photographs that may be taken include the test unit before test; during test setup; at the time of ignition (with door or flap enclosed); at 30 seconds, 1 minute, 2 minutes, 3 minutes, 5 minutes, 7 minutes, and 10 minutes into the test; and at 5-minute intervals thereafter. Include detailed photographs showing any damage sustained as a result of the fire. Photographs taken during the test shall have a dark background to show smoke in contrast.

B1.6.4 Inspection

After the test has been terminated, the test unit will be inspected for damage. The doors will be opened and the extent of combustion of the waste materials will be noted. Photographs will be taken of these waste materials and any damage to the cart or compartment, or lack of damage. Care should be taken to completely document any damage, from simple smoke stains and melting of trays to major burnthrough of any panels.

B1.7 Report

B1.7.1 Identification of Sample

Completely identify the unit being tested and its intended use.

B1.7.2 Description

The results of the test will be described in a concise manner regarding any observable smoke or fire from within the item. Any deterioration, burnthrough, or deformation of the panels caused by heat or flame will be noted and described with the time of occurrence. Any damage to the item or surrounding structures during the test will be noted. Any damage to the contents will be described, including the degree of combustion of the articles placed within the unit and damage to trays and seals.

B1.7.3 Temperature Versus Time Plot

A temperature versus time plot may be supplied in the report if temperature is monitored during the test. An example of a temperature versus time plot is shown in figure B1-1.

B1.7.4 Test Photographs

The photographs taken (per section 10.6.3) of the test method will be included with the report. Photocopies of photographs are not acceptable. A short description will accompany each photograph.

B1.7.5 Acceptance of Results

A statement as to whether the acceptance criteria are met will be made in the report.

B1.7.6 Statement of Conformity

The statement of conformity sheet will be included with the test report.

B1.7.7 Summary of Data

A summary may be prepared and included with the test report.

B1.8 Requirements

B1.8.1 The temperature indicated by the thermocouple(s), if used, after ignition will rise rapidly, peak, and then fall steadily as the fire burns out. To be valid, the test will have a definitive peak to demonstrate that a fire has taken place. If no peak is visible or a good flame front cannot be achieved, the test will be repeated up to three times to demonstrate that sufficient effort has been made to produce such a temperature peak or flame front.

B1.8.2 The test unit will be able to contain a fire within the enclosure.

B1.8.3 Fire/flame will not penetrate through or issue from the bottom, top, or sides of the waste compartment/container, and adjacent material will not be ignited by heat from the test article.

B1.8.4 Smoke will be contained within the waste compartment/container to the extent that the smoke level produced in the cabin does not create a hazardous condition or interfere with firefighting procedures.

Chapter B2
Test Method To Determine The Flammability And Flame Propagation Characteristics Of Thermal/Acoustic Insulation Materials

B2.1 Scope

B.2.1.1 Applicability

This test method is intended for use in determining the flammability and flame-propagation characteristics of thermal acoustic insulation materials when exposed to radiant heat and an open flame.

B2.2 Definitions

B2.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the sample. The ignition time for this test is 15 seconds. In certain atypical cases, the ignition time may be extended to 30 seconds (see section B2.2.5, After-Flame Time).

B2.2.2 Flame Profile (Pilot Burner)

The flame profile is an immediate “footprint” that occurs on a material at the start of a test as a result of pilot burner flame impingement.

B2.2.3 Zero Position

The zero position is the pilot burner application point on the test sample, which is level with the top surface of the sliding platform upper flange. The zero position coordinates are centerline (± 0.25 inch) with the sliding platform opening (front to back) and 4.5 ± 0.5 inches (114 ± 13 mm) from the inside right edge of the platform frame.

B2.2.4 Flame Propagation

Flame propagation is the leftmost spread of visible flame or flashing that occurs on a sample. It is referenced from the centerline of the pilot burner (zero position).

When the propane flame is brought into contact with certain materials, such as film/fiberglass assemblies, the pilot flame bores a round hole through the material approximately 1.5 inches (38 mm) in diameter. With materials such as foam and some rigid materials, the initial appearance of the flame on the sample surface is that of a “fanned out” flame profile. This is not flame propagation. This also applies to interface hook-and-loop and interface damping systems.

Melting or shrinking is not considered flame propagation. Materials that melt can alter the flame profile of the pilot burner if the material melts to the point that the pilot burner flame is directly contacting the backing board. Testing of such materials needs to be observed closely to determine whether the material is burning or simply melting. Material burning beyond the allowable limit is considered flame propagation, regardless of the flame profile or the influence of the flame profile on the backing board.

Occasionally, a material may exhibit “flashing” behavior. Flames appear on the test sample some distance away from the zero position (beyond the allowable limit). This is considered flame propagation.

B2.2.5 After-Flame Time

After-flame time is the time in seconds that any portion of the sample continues to burn or flash after the burner flame is removed. Glowing is not considered after-flame.

For after-flame time only, it is possible that certain materials with good propagation protection characteristics can show modest after-flame time beyond the limit. In some cases, after-flame can be attributed to the specific 15-second exposure time in the test. Because the exposure time was mainly derived from tests on thin film materials, extended exposure may be meaningful for other types of materials. If the after-flame time is above the allowable limit, but the material does not propagate, it is acceptable to apply the burner flame for 30 seconds. The same pass/fail criteria are applied, and if the material passes with a 30-second exposure, it can be used. The earlier tests with a 15-second exposure must be disregarded.

B2.2.6 Radiant Heat Source

The radiant heat source is an electric panel having six 3-inch- (76.2 mm) wide emitter strips (see section B2.3.2 Electric Radiant Heat Source).

B2.2.7 Thermal/Acoustic Insulation

Thermal/acoustical insulation is a material or system of materials used to provide thermal/acoustic protection. Examples include fiberglass, foam, and other batting materials, which may be encapsulated by moisture barrier film covering.

B2.2.8 Test Series

A series of tests conducted between chamber calibration and system recheck (see sections B2.5.2 Zero Position Calibration and B2.5.3 System Recheck Procedure).

B2.2.9 NIST

The National Institute of Standards and Technology (USA).

B2.2.10 NIST Traceability

A calibration entity using NIST traceable calibration instrumentation.

B2.2.11 Heat-Flux

The intensity of the thermal environment to which the sample is exposed when burned. In this test method, the total heat flux is 1.5 BTU/ft^2sec (1.7 W/cm^2).

B2.3 Test Apparatus

B2.3.1 Test Chamber

Tests must be conducted in a radiant panel test chamber as shown in figure B2-1. The test chamber is 55 ± 1 inch (1397 ± 25.4 mm) wide, 20 ± 1 inch (508 ± 25.4 mm) deep (front to back), and 29 ± 1 inch (737 ± 25.4 mm) high from the top of the sliding platform to the top of the chamber frame. All dimensions are taken from the inside of the insulated walls.

The sides, back, and top of the chamber must be insulated with 0.5-inch-thick (12.7 mm), high-temperature insulation material. On the front side, a draft-free, high-temperature glass viewing window must be installed. The window is 9 ± 3 inches (229 ± 76 mm) high by 48 ± 4 inches (1219 ± 102 mm) long. The sliding platform drawer sits below the viewing window. Refer to appendix M for more details on the test chamber.

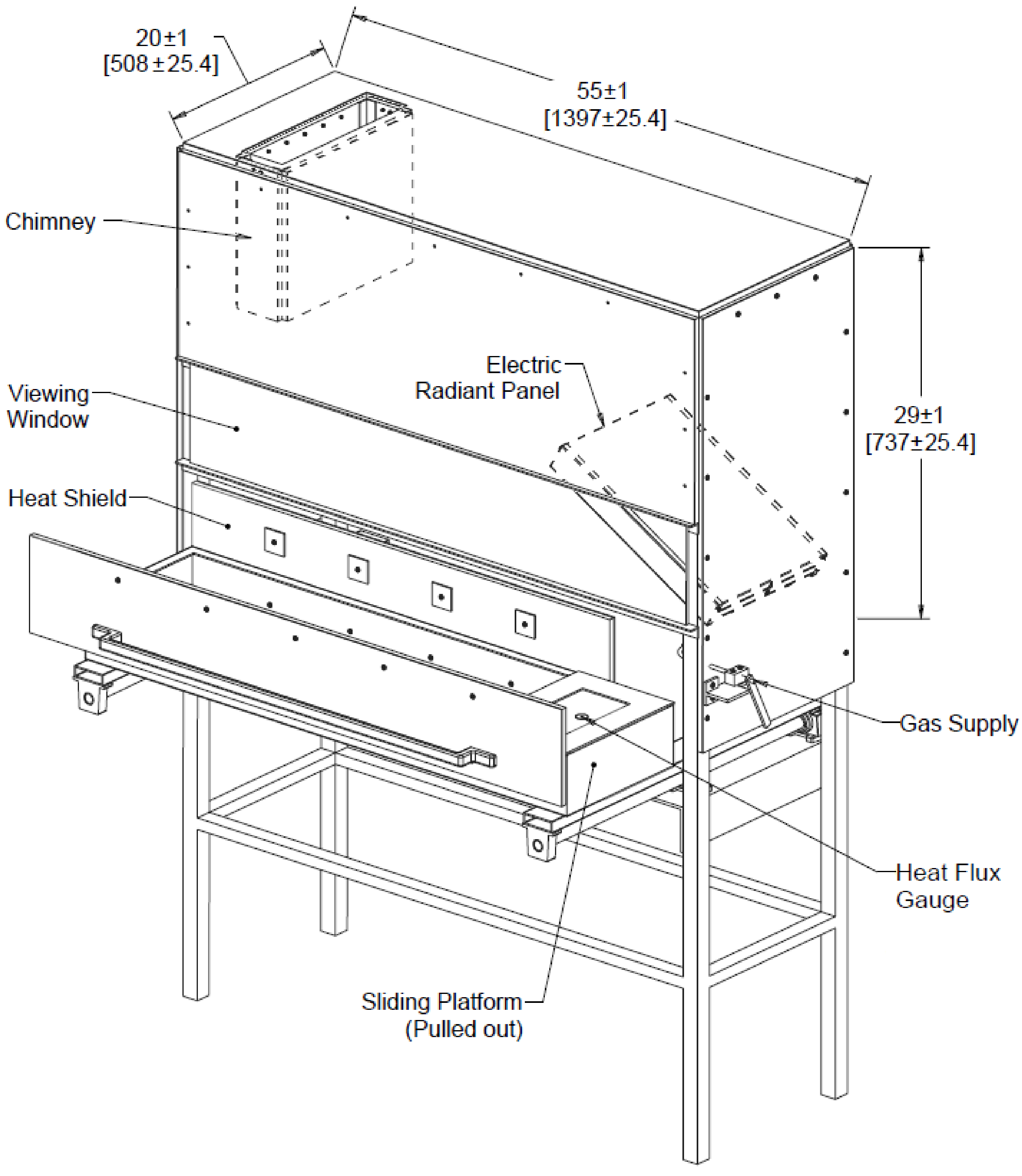


Figure B2-1. Test chamber

The chamber must have an internal chimney that extends to and terminates at the top of the chamber. The chimney is located at the opposite end of the chamber from the radiant heat source (see figure B2-2). Test results can be significantly influenced by the condition of the chimney in the test chamber, which must always be open and clear of obstruction. Refer to appendix M for more details. The test chamber should be located under an exhaust hood to facilitate clearing exhaust smoke during each test.

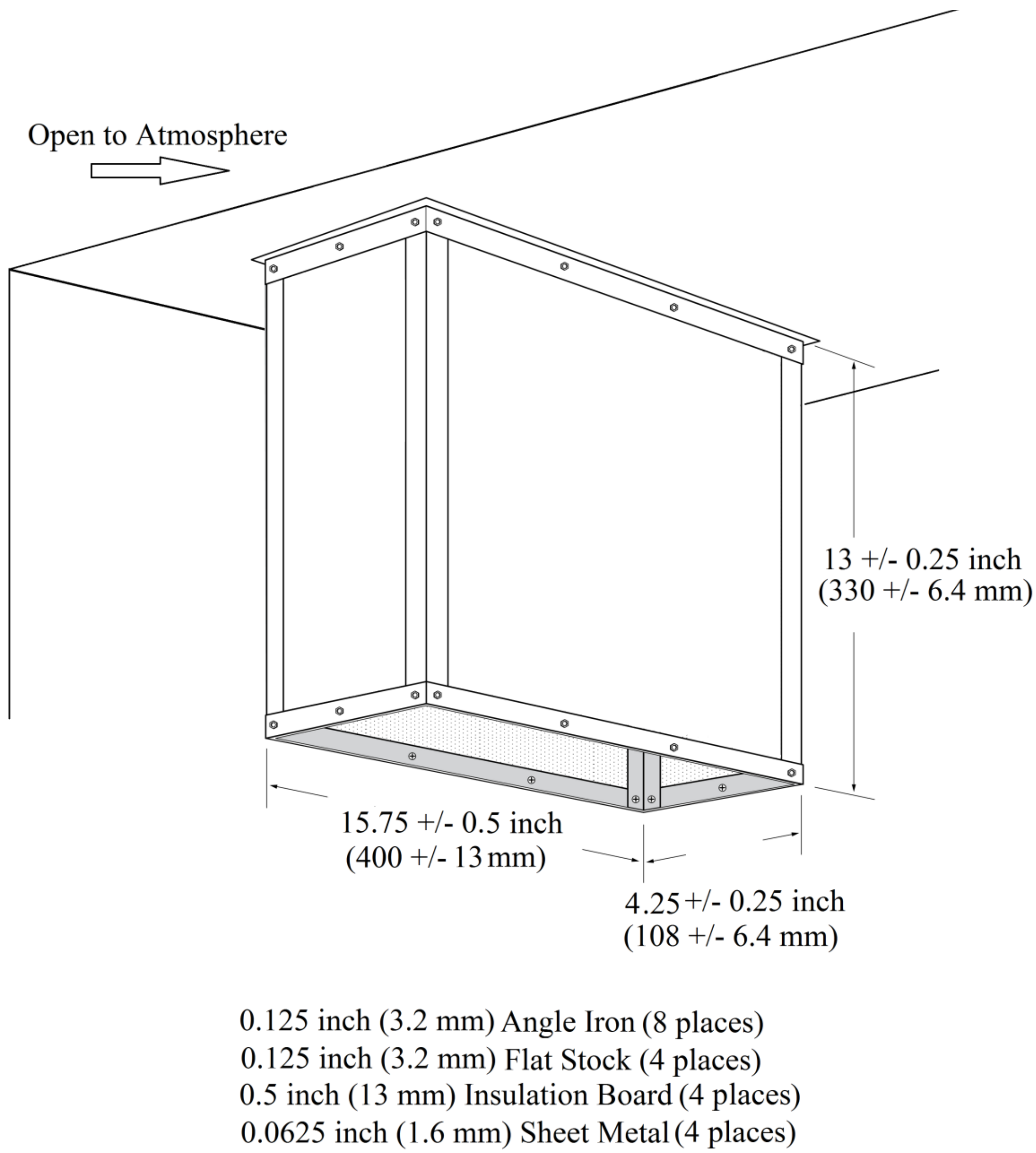


Figure B2-2. Interior view of internal chimney

B2.3.1.1 Draft Check

A draft check must be completed periodically if the test chamber is physically moved or if the exhaust system has been changed. Ensure that the chamber is draft free prior to turning on the power to the radiant heat source. To verify this, measure the airflow above the internal chimney with an anemometer device to ensure there is no airflow. Alternatively, an incense cone or other smoke-producing item can be placed on the sliding platform at the zero position with the platform drawer closed.

NOTE: the sliding platform must have insulation boards covering the entire length of the platform for either method of draft checking.

Observe the smoke behavior. If the smoke rises vertically without any drift, it can be regarded as draft free. If testing is performed with an exhaust hood running, the airflow check must be performed with the exhaust hood on.

B2.3.2 Electric Radiant Heat Source

The electric panel must have six 3-inch (76.2-mm) wide emitter strips, as shown in figure B2-3. The emitter strips must be perpendicular to the length of the panel. The panel must have a radiation surface of 12.6 by 18.75 inches (321 by 476 mm) and be capable of operating continuously at the typical temperature range required to maintain the specified heat flux. The panel surface should be kept clean using a soft bristle brush or soft cloth. A plastic scraper can be used if any debris sticks to the surface. Never use anything metal, such as a wire brush, to clean the panel surface. Refer to appendix M for more details on the electric radiant heat source.

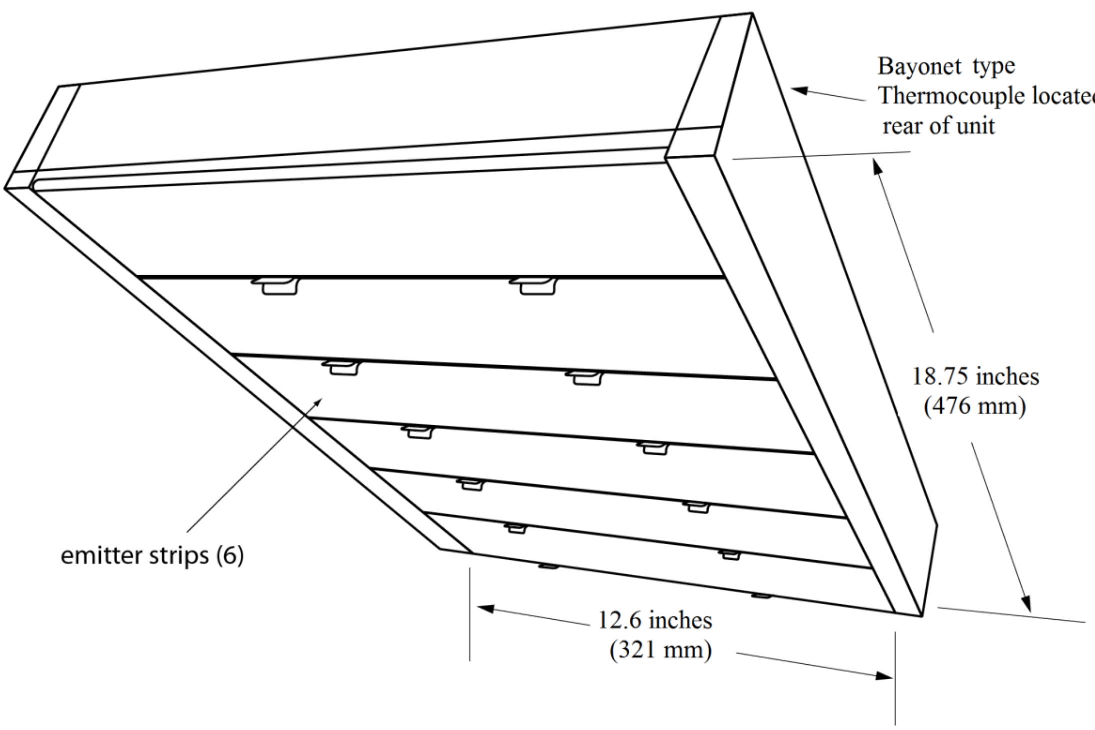


Figure B2-3. Electric radiant panel

B2.3.2.1 Electric Radiant Panel Placement

The electric panel must be mounted in the test chamber at 30 ±1º to the horizontal sample plane and 7.5 ± 0.125 inches (191 ± 3 mm) above the zero position. Refer to appendix M for proper positioning of the electric radiant panel.

B2.3.3 Sample Holding System

The drawer (also called the sliding platform) serves as the housing for test-sample placement in a fixed and level position (see figure B2-4). The drawer must be at least 2 inches (51 mm) deep and may be up to 6 inches (152 mm) deep. It may be necessary to use shims or multiple sheets of insulation boards to obtain the correct height for a material to be level with the bottom surface of the sliding platform upper flange. The entire opening on the inside of the drawer must be covered during testing to prevent convective airflow. Refer to appendix M for more details on the sample holding system.

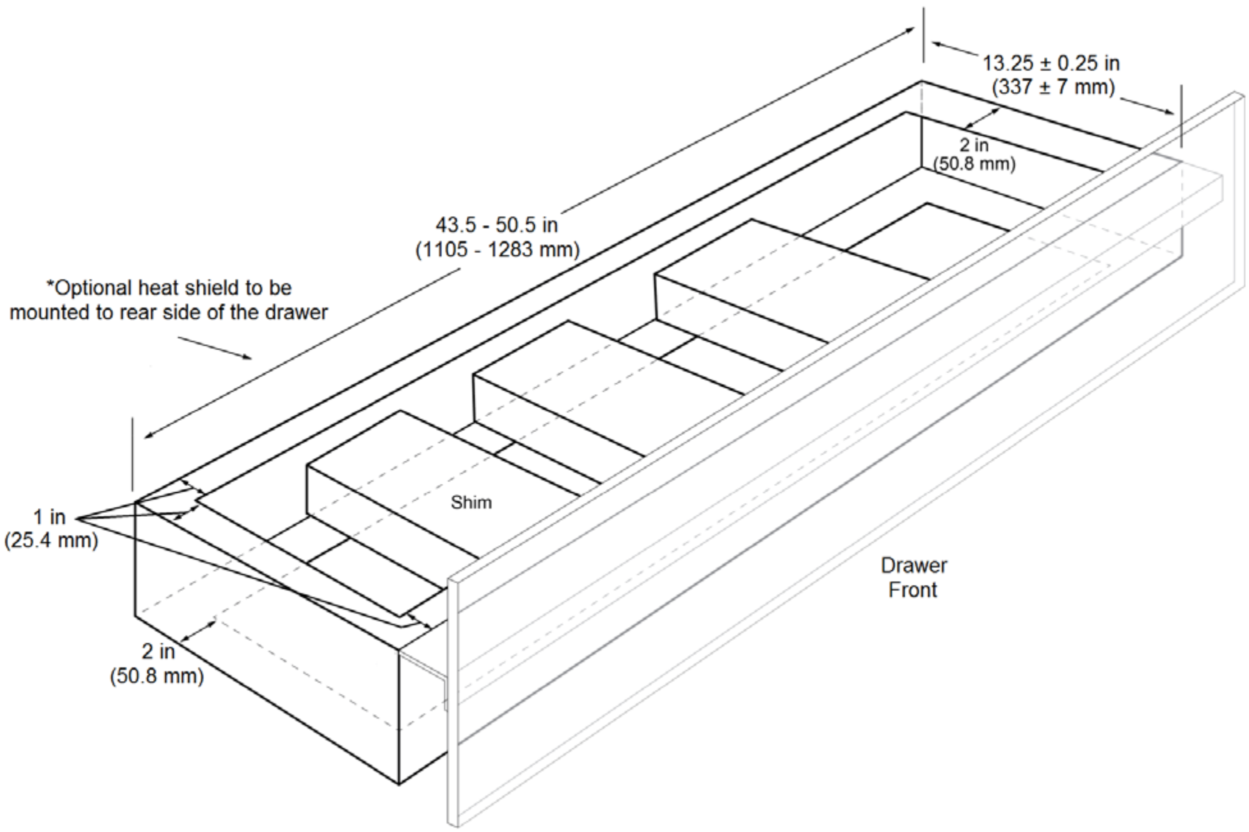


Figure B2-4. Sliding platform

B2.3.3.1 Standard Retaining Frame

A retaining frame is required and must secure the sample in place during testing. The top flange of the frame (horizontal) sits on top of the sliding platform upper flange, and the bottom flange (vertical) compresses the film of the sample around the inside perimeter of the frame to help hold it in place (see figure B2-5). It may be necessary to adjust the sample up or down to maintain the 7.5 ± 0.125-inch (191 ± 3-mm) distance from the sample to the radiant panel at the zero position.

Foam samples tend to rise during testing, which can make flame propagation difficult to determine. It is acceptable to hold the foam sample in place with safety wire if the wire is positioned away from the propane igniter and does not affect the flame propagation.

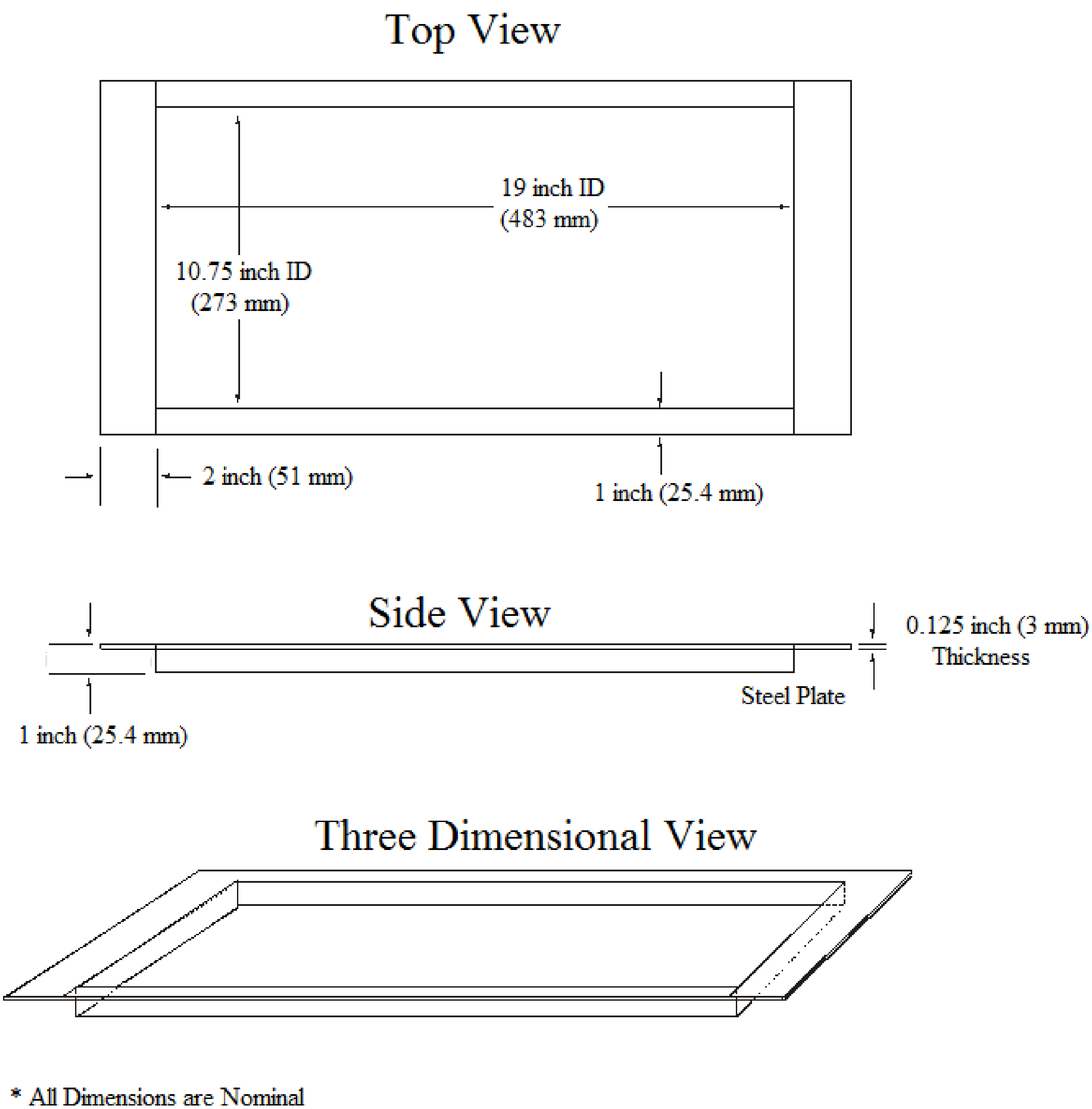


Figure B2-5. Standard retaining frame

B2.3.3.2 Hook-and-Loop Retainer Frame

When testing hook-and-loop materials, a smaller retaining frame must be constructed to keep the sample in place. The frame is fabricated of mild steel with a thickness of 0.125 inches (3.2 mm) (see figure B2-6).

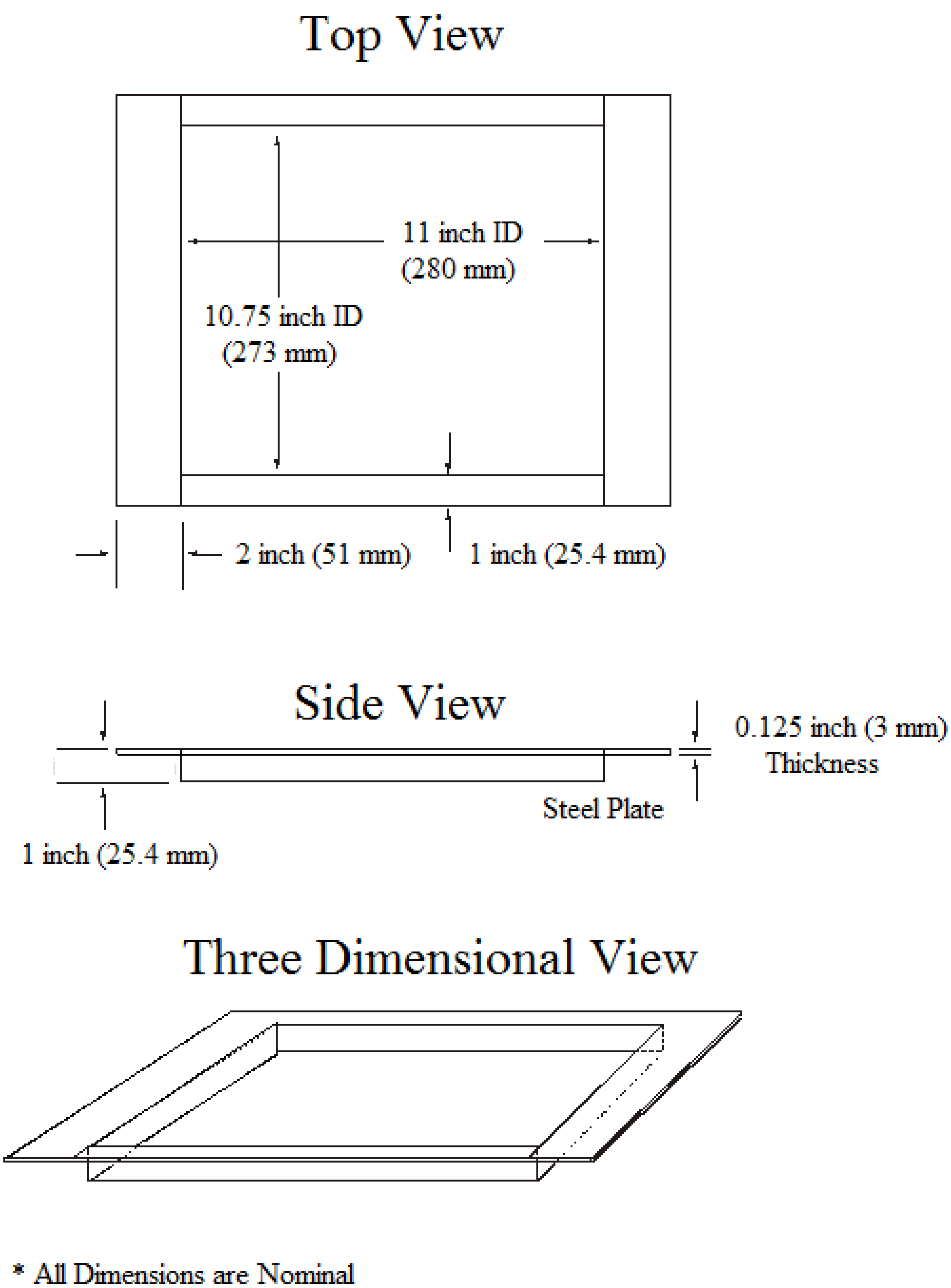


Figure B2-6. Hook-and-loop retainer frame

B2.3.4 Pilot Burner

The pilot burner used to ignite the sample must be a commercial propane Venturi torch with an axially symmetric burner tip and a propane supply tube having an orifice diameter of 0.006 inch (0.15 mm) (see figure B2-7). The length of the burner tube must be 2.875 inches (73 mm). The propane flow must be adjusted via gas pressure through an inline regulator to produce a blue inner-cone length of 0.75 inch (19 mm). A removable 0.75-inch (19 mm) guide, such as a thin strip of metal, may be connected to the top of the burner to aid in setting the flame length. The overall flame must be approximately 5 inches long (127 mm) (see figure B2-7). An optional high-temperature glass viewing window located on the left wall of the chamber is permitted to ensure proper flame length if it is no larger than 6 inches by 6 inches (152 by 152 mm).

Provisions must be made to move the burner from the test position so the flame is horizontal and at least 2 inches (50.8 mm) above the sample plane (standby position). Do not allow the flame to impinge on the radiant panel. Refer to appendix M for more details on the pilot burner.

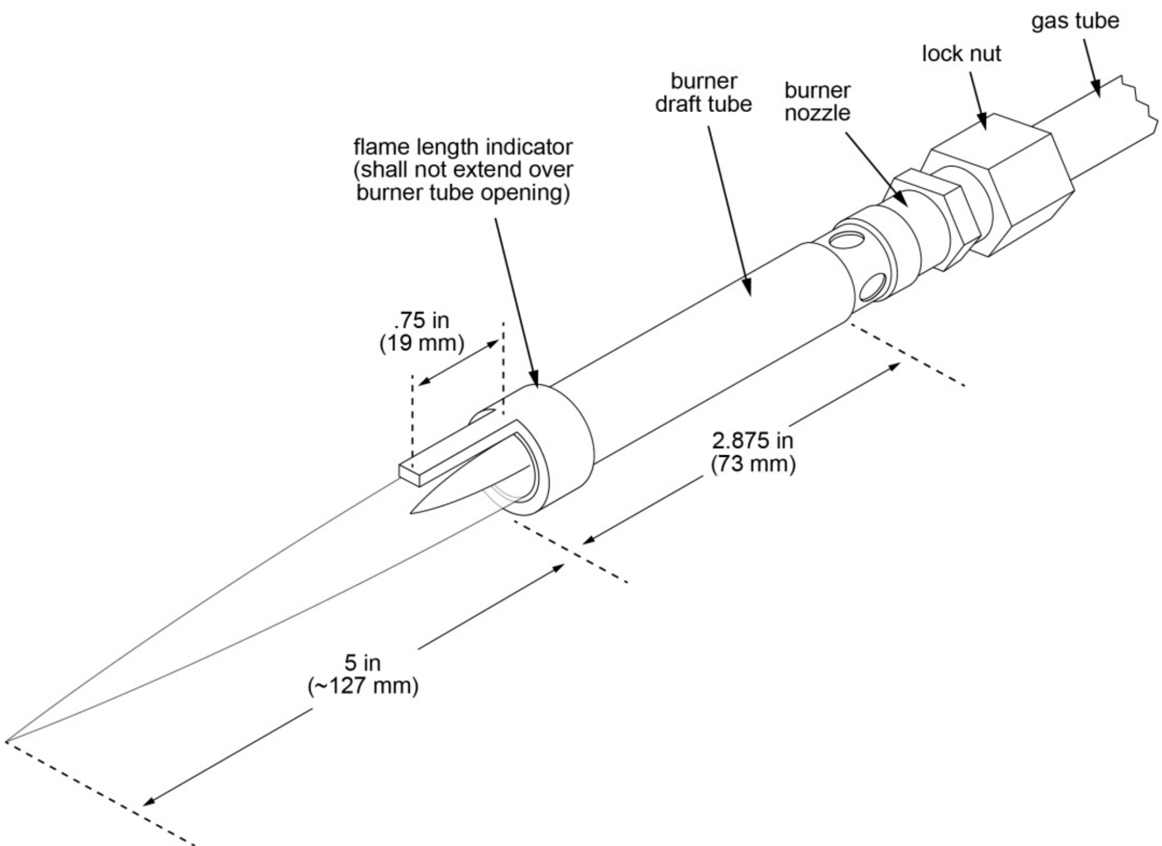


Figure B2-7. Propane Venturi torch (pilot burner)

B2.3.5 Chamber Temperature Thermocouple

A chamber temperature thermocouple is recommended as a third point of reference for overall system health monitoring. It is used in conjunction with the heat-flux measurement and power-controller setpoint. The thermocouple must be a 0.0625-inch (1.59 mm) diameter, stainless-steel, jacketed Type K (chromel-alumel) thermocouple, located inside the chamber through a small hole drilled through the back wall. See appendix M for more details on the location of the chamber thermocouple.

Once heat flux is determined and the system is calibrated and ready for testing, the nominal operating range is typically 450 ± 100°F (232 ± 55°C). This temperature should remain consistent (± 5%) in day-to-day testing for an individual machine, but may vary much more across different machines.

B2.3.6 Calibration Assembly

B2.3.6.1 Heat-Flux Gauge

A water-cooled, Gardon-type heat-flux gauge (HFG) must be used to determine the total heat-flux at three positions within the chamber. The HFG cooling water temperature, pressure, and flow shall be maintained within the manufacturer's recommendations. Ensure no condensation occurs on the gauge surface at any time (often caused by cooling water being too cold).

The HFG must have a thin, full-faced, opaque coating of high-temperature, high-emissivity, ultra-flat black paint. The sensitivity of the gauge is a function of the surface condition. Changes in the coating may cause drift in the overall characteristics of the gauge. Regularly inspect the measuring surface for physical damage or dust particles that may have accumulated. Cleaning can be accomplished by gently wiping a soft, water-dampened sponge across the sensor face. Damage done to the coating during the cleaning process will affect the measurement accuracy of the sensor. To maintain accuracy, the measuring surface must be recoated at regular intervals, followed by annual recalibration. See appendix H for full details on the HFG and its required calibration.

B2.3.6.2 HFG Calibration Fixture

The center of an HFG must be mounted in the zero position, as defined in B2.2.3, to determine total heat-flux on test samples. The HFG must be mounted in a supporting device protruding through 0.5-inch-thick (12.7 mm) rigid refractory board. Alignment features may be added to help secure the fixture in the correct position. The holder must be constructed so it can be easily moved from one position to the next when conducting a three-position check, or it must be able to measure all three positions at the same time (see section B.2.5.4 3 Position Check). Refer to appendix M for more details.

B2.3.7 Instrumentation and Equipment

B2.3.7.1 Data Acquisition

A computerized data-acquisition system must be used to record the output of the HFG and the chamber thermocouple. The data-acquisition system must be capable of recording the HFG output every second during calibration and calculating a 5-minute average of the data. An acceptable data-acquisition system is a 22-bit, analogue-to-digital converter with an accuracy of 0.02 percent of the reading. The data-acquisition system must be calibrated annually to NIST traceability.

B2.3.7.2 Timing Device

A stopwatch or other device, accurate to ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of flame application (ignition time) and after-flame. It is acceptable to use an automatic timer for moving the pilot burner in and out of test position. The timing device must be calibrated annually to NIST traceability.

B2.3.7.3 Ruler

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) must be provided to measure the flame propagation length.

B2.4 Test Samples

B2.4.1 Number of Samples

A minimum of three samples must be tested.

B2.4.2 Sample Conditioning

Condition test samples at 70 ± 5º F (21 ± 2º C) and 55 ± 10% relative humidity for a minimum of 24 hours prior to testing. It is permissible to remove more than one sample at a time from the conditioning chamber if the samples are placed in a closed container (a plastic bag is acceptable). The samples must be protected from contamination until tested.

B2.4.3 Sample Construction

Test samples must include all materials used in construction of the insulation, including batting, film, scrim, and tape. Thermal/acoustic insulation typically consists of a thin film moisture barrier encapsulating a batting material. There are also foam insulation materials that may or may not use a separate moisture barrier. There are frequently detail materials that need to be accounted for in addition to the basic materials that make up the insulation. These detail materials include thread, tapes, and hook-and-loop fasteners. With the exception of "small parts," detail materials such as these are considered part of the construction of the material and have been shown to influence whether the material will propagate a fire. Because these detail features of the construction are not uniformly applied and may be used with several different basic materials, fabrication of test samples requires special consideration of these detail materials in addition to that of the basic materials.

B2.4.3.1 Rigid/Nonrigid Materials (Mated)

This section describes testing of materials, such as film/fiberglass assemblies, quilted blankets, thread, and foam, and auxiliary materials, such as felt and coated fabric (used in addition to batting and cover material). Use of the standard retainer frame is required when testing these materials (see section B2.3.3.1).

For oriented film cover material, the term "fill" is typically used for transverse direction and "warp" is used for machine direction. If there are sufficient data available that show no difference in test results between the warp and fill direction, then it is acceptable to test just the fill direction. If a new material is tested, and there is no history on this material, then both warp and fill directions must be tested.

Cut a piece of core material, such as foam or fiberglass, and cut a piece of film cover material (if used) large enough to cover the core material. Heat sealing is the preferred method of preparing fiberglass samples because they can be made without compressing the fiberglass. Cover materials that are not heat sealable may be stapled, sewn, or taped if there is enough cover material to be drawn down the sides without compressing the core material. The fastening means must be as continuous as possible along the length of the seams or enough to prevent the cover from moving once the frame secures the sample. The sample thickness must be of the same thickness as installed in the aircraft.

To facilitate proper placement of samples in the sliding platform housing, cut nonrigid core materials (such as fiberglass) 12.5 inches (318 mm) wide by 23 inches (584 mm) long. Rigid materials may be more difficult to fit beneath the sliding platform upper flanges, so the width can be reduced. Cut rigid materials (such as foam or silicon assemblies) 11.5 ± 0.25 inches (292 ± 6 mm) wide by 23 inches (584 mm) long to fit properly in the sliding platform housing and provide a flat, exposed surface.

B2.4.3.2 Tape

Tapes are used both during initial production and in the process of making repairs or facilitating material replacements on airplanes in service. It is not practical to test each possible configuration of tape and film/batting material. To simplify this process, the following procedure has been developed to show compliance for the use of tape. It is also acceptable to test the tape in its installed configuration, which will qualify that configuration only.

Each type of tape requires qualification on each material on which it is used. It is acceptable, however, to use a standard batting material for all tape/film combinations.

Four strips of 2-inch-wide (51 mm) tape (as supplied by the manufacturer) must be placed on the test sample. The tape strips must be cut long enough to cover the sample from front to back. The first strip of tape is applied at the right side of the sample and each strip of tape overlaps the preceding strip by 0.5 ± 0.125 inch (12.7 ± 3 mm) in the right-to-left direction. The tape must be arranged so that the centerline of the pilot burner igniter flame contacts the seam of the first overlap. Figure B2-8 shows the general arrangement. It will be necessary to make a template to determine how far from the right edge of the sample to place the first strip of tape. This is necessary to ensure that the burner flame contacts properly.

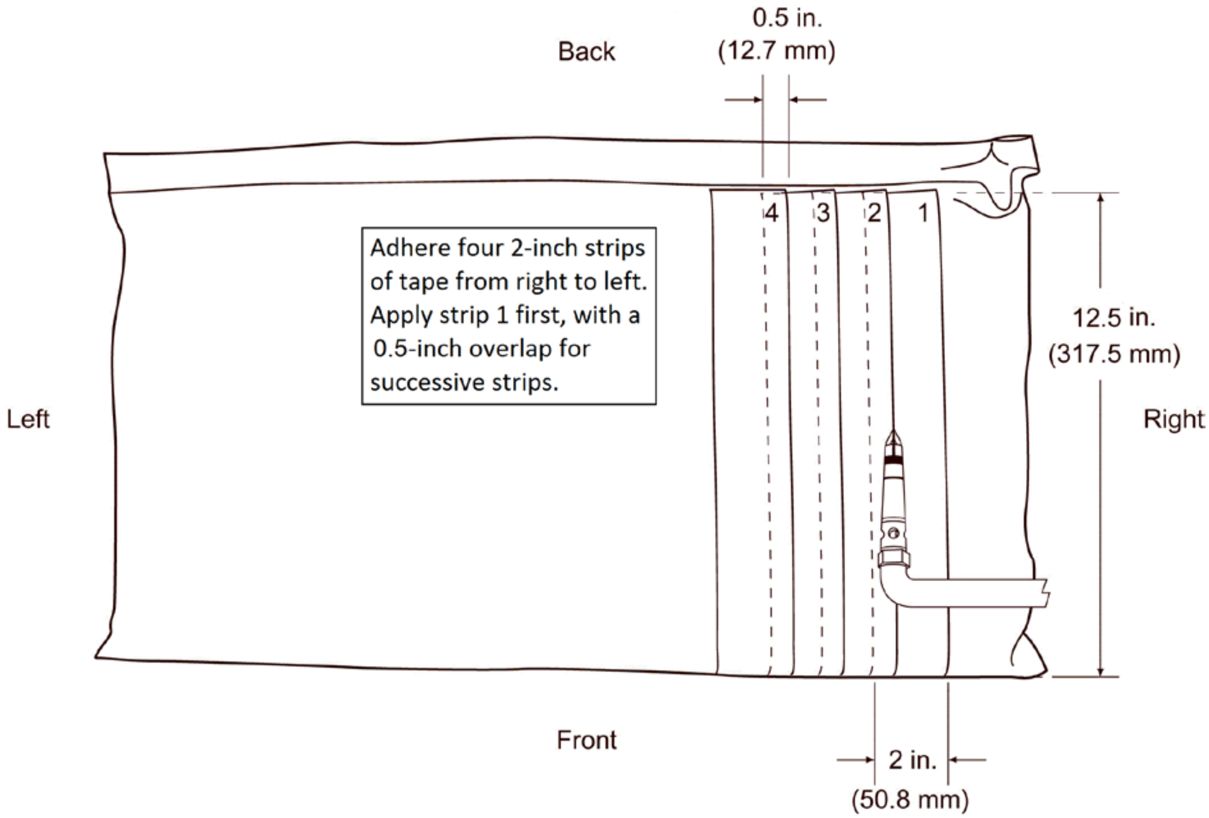


Figure B2-8. Tape configuration (top view)

If the tape is not supplied in 2-inch (51 mm) widths, but only in wider sizes, cut the tape down to 2 inches (51 mm). If it is narrower than 2 inches (50 mm), use the actual width. Use of the standard retaining frame is required when testing tapes (see section B2.3.3.1).

B2.4.3.3 Hook-and-Loop

Separate insulation blankets are often connected using hook-and-loop fastening systems. Depending on the installation, hook-and-loop fasteners could also be used to attach the insulation to the airplane structure. As with tape, there are many possible combinations and orientations of fastener and film/batting, so testing each one could be impractical. However, the influence of the hook-and-loop on fire safety is potentially significant and must be addressed in testing. A test procedure has been developed to simplify the certification process. Samples are tested as mated components to address the different uses of hook-and-loop materials. Whereas hook-and-loop material is not always mated when installed (e.g., there may be small segments of unmated material), testing indicates that materials that pass when mated are satisfactory.

Tests conducted on 1-inch-thick (25.4 mm) batting material are used to substantiate the hook-and-loop on all other thicknesses and densities of that material. This thickness will keep the upper surface at the standard height below the radiant panel and allow the pilot burner flame to impinge on the interface of the hook-and-loop. Because each core/outer material combination will require substantiation in the standard configuration, the hook-and-loop test may be conducted with any acceptable core material.

Encapsulated material samples are constructed by folding the material with the mated edge around the core material and then stapling the sample along the non-mated edges. Figure B2-9 shows an example of the configuration for mated samples. Note that in this case, the sample size and orientation relative to the pilot burner are different than for a typical test sample. Hook-and-loop strips 1 inch (25.4 mm) wide must be attached within 0.25 inch (6 mm) of the sample edge.

The sample must be 12 inches (305 mm) long and 4 inches (102 mm) wide, and placed so that it touches the back and right vertical surface of the sliding platform drawer level with the bottom surface of the sliding platform upper flange. Adjusting the height of the sample may be necessary to ensure that the relationship to the pilot burner is maintained to keep the junction or interface of the hook-and-loop exposed to the tip of the burner flame. Use of the hook-and-loop retaining frame is required when testing these materials (see section B2.3.3.2). Figure B2-10 shows the sample with the retaining frame in place.

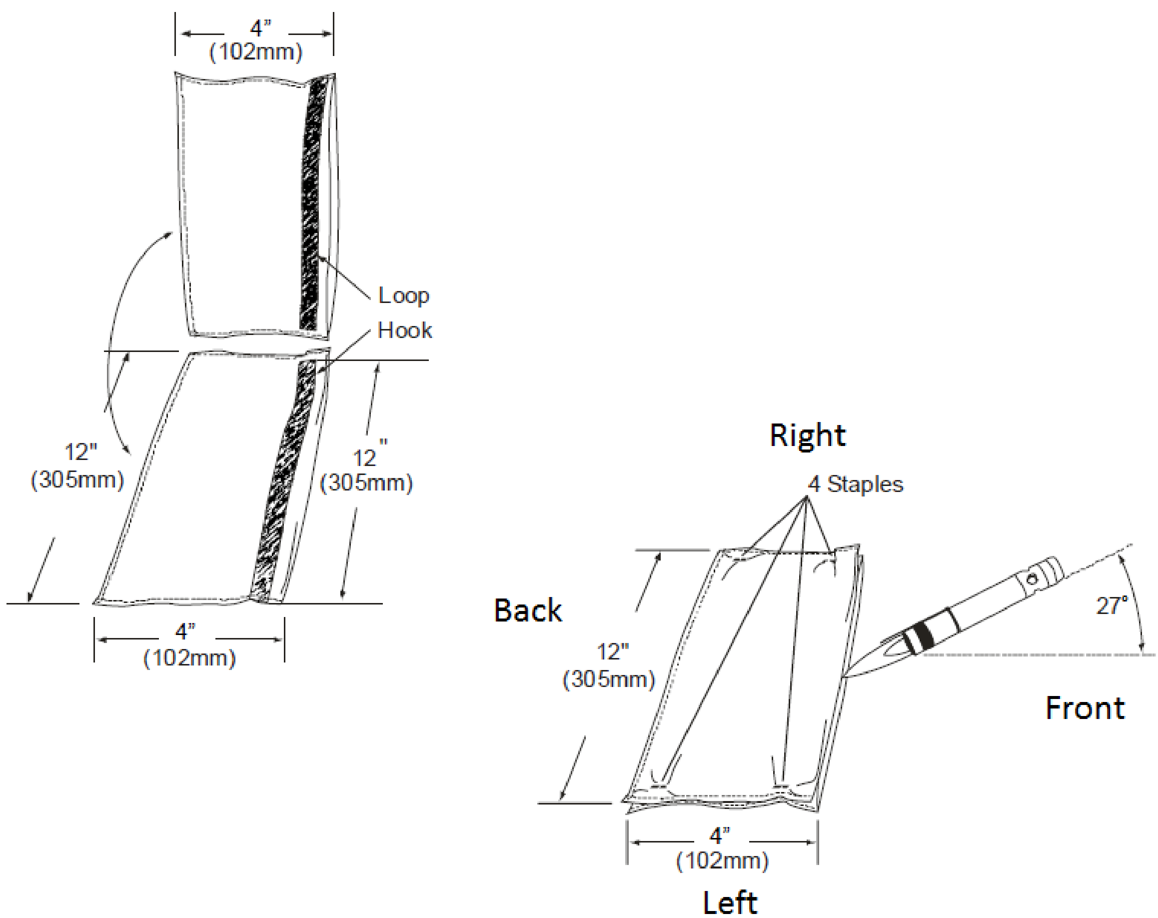


Figure B2-9. Hook-and-loop configuration

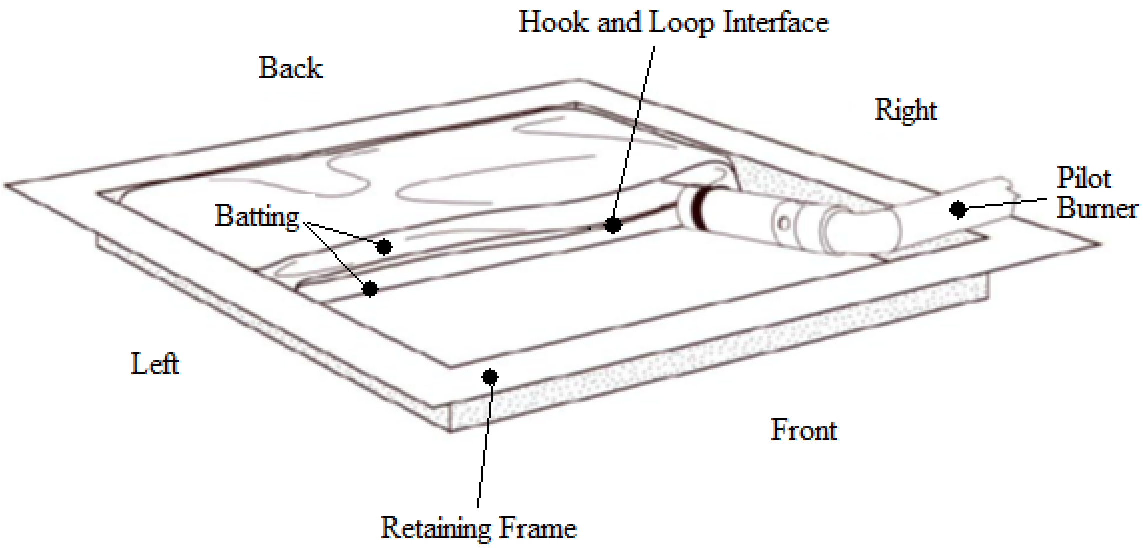


Figure B2-10. Hook-and-loop retainer frame securing material

Three tests are conducted with each combination of mated samples using the same pass/fail criteria as specified in section B2.8. Once this combination of materials (hook-and-loop, whatever material it is attached to, and any other insulation materials contained in the sample) have been substantiated, that combination of materials may be mated to any other substantiated combination of materials without further test.

B2.4.3.4 Damping Systems

Structural damping materials may be considered thermal/acoustic insulation, depending on their specific configuration and use. These materials are often a soft aluminum sheet bonded to the airplane structure. The aluminum sheet itself is not susceptible to flame propagation and is not itself insulation. Small aluminum sheets bonded directly to the airplane skin with a layer of adhesive would not be considered thermal/acoustic insulation. Damping materials that include a layer of foam or other material would be treated as thermal/acoustic insulation, and therefore must be tested for flame-propagation characteristics.

The sample must be 12 inches long and 4 inches wide, and must be placed so that it is level with the top surface of the sliding platform upper flange (see figure B2-11). When testing at the interface of the insulating material and substrate, some adaptation is necessary to precisely position the test sample. To determine the correct placement (front to back) for the test sample, place a piece of damping system (material) bonded to a 0.060 ± 0.010-inch-thick (1.5 ± 0.25 mm) piece of aluminum sheet in the radiant panel test apparatus sliding platform.

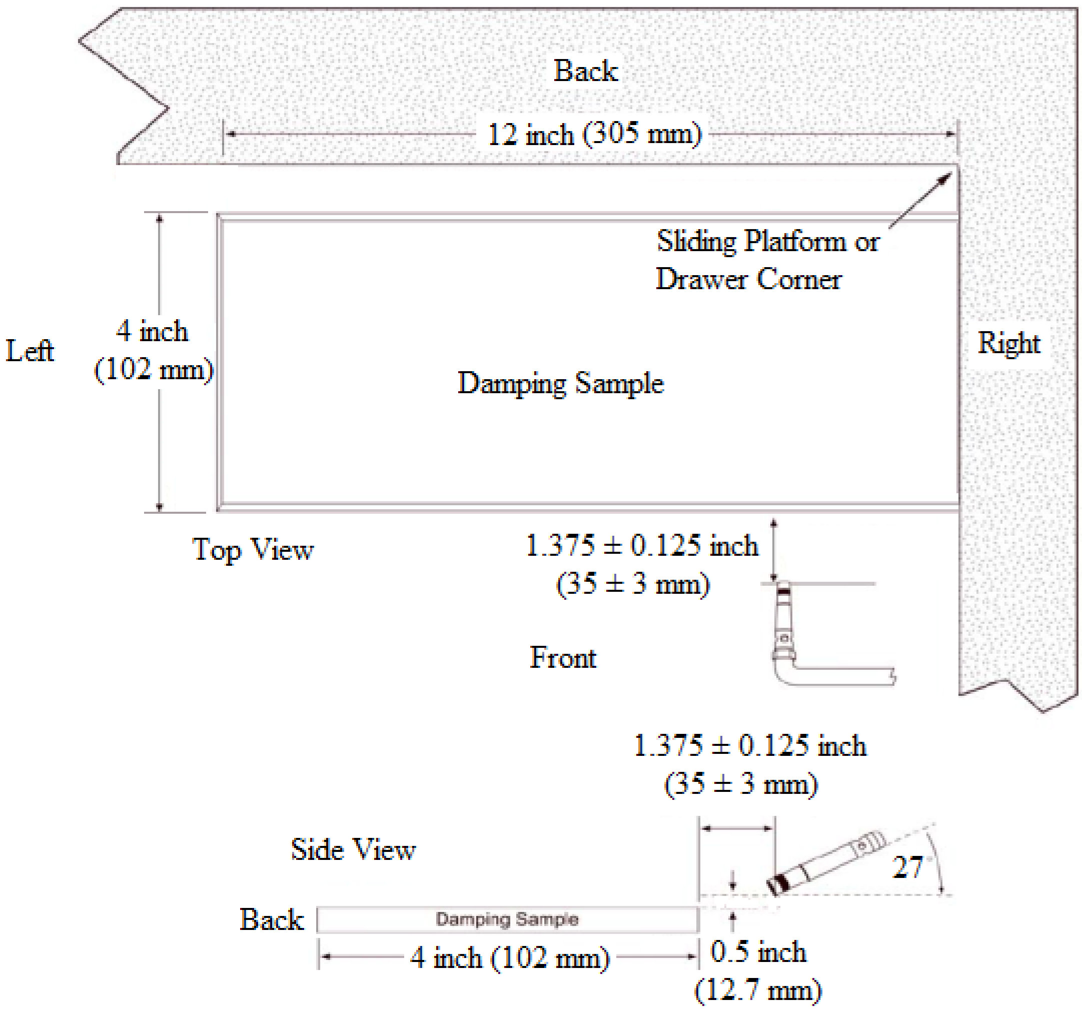


Figure B2-11. Damping material configuration

With the pilot burner in the down position and the burner guide removed, the distance from the bottom of the burner to the front edge of the sample must be 1.375 ± 0.125 inches (35 ± 3 mm). A metal shim can then be made and sized accordingly to be placed behind the sample so that the 4-inch-wide sample is placed in the correct position for each test. This measurement and shim-size determination are needed for each lab because slight variations may exist from one apparatus to another. The sample must be placed against the right side of the upper flange on the drawer. Figure B2-11 shows the position of the sample and burner. The top of the sample must be at the proper height (see section B2.2.3 Zero Position). Because the igniter angle is 27 degrees, the flame then impinges the interface of the sample and the aluminum sheet. No sample retaining frame is required when testing these materials.

B2.5 Preparation of Apparatus

B2.5.1 General Information

Prior to daily testing, a “Zero Position Calibration” (section B2.5.2) and “System Upset Check” (section B2.5.3) must be conducted. A “Recheck” must be conducted immediately following the completion of a test series to ensure data are valid. If the recheck heat-flux value is not within range, the test data are considered to be invalid (section B2.6.4). Once a recheck is conducted, material testing must be continued within 30 minutes, or the equipment must be allowed to cool to ambient conditions (approximately 1 hr) if testing has been completed. Heat flux must be calculated using a 5-minute rolling average.

Calibration of the test apparatus must be completed no sooner than 25 minutes and no later than 90 minutes after turning the radiant panel on. If calibration is not able to be completed within 90 minutes, it could indicate a problem with the machine, and the equipment must be allowed to cool to ambient conditions (approximately 1 hr) before repeating the “Zero Position Calibration” and “System Upset Check” procedure.

NOTE: The actual heat flux generated by the radiant panel has a direct influence on test results. Experiments suggest that variations in heat flux from the ranges specified can influence both after-flame time (after removal of the pilot burner flame) and propagation length, although not necessarily in the same way. A slightly higher heat flux might be critical for one parameter, whereas a slightly lower heat flux might be critical for the other parameter. It is essential that heat flux be maintained as specified in table B2-1.

Table B2-1. Heat-flux ranges for thermal/acoustical insulation test

	W/cm^2			
Range	Zero Position	#1 Position	#2 Position	Recheck
High	1.72	1.73	1.67	1.75
Nominal	1.70	1.70	1.64	1.70
Low	1.69	1.66	1.57	1.64
	BTU/ft^2*sec			
Range	Zero Position	#1 Position	#2 Position	Recheck
High	1.51	1.52	1.47	1.54
Nominal	1.50	1.50	1.44	1.50
Low	1.49	1.46	1.38	1.44

B2.5.2 Zero-Position Calibration Procedure

B2.5.2.1 Install the HFG calibration fixture at the zero position. Place a sheet of noncombustible material on top of the sliding platform adjacent to the calorimeter fixture (to the left) to prevent heat loss during calibration. The entire opening of the inside of the drawer must be covered.

B2.5.2.2 Ensure the HFG surface is clean, properly aligned, and cooling water is flowing. Close the sliding platform.

B2.5.2.3 The pilot burner must be off and in the down position (test position).

B2.5.2.4 Begin heating and allow a minimum time period of 25 minutes for equipment to stabilize. The temperature of the radiant panel must reach its set point.

B2.5.2.5 Calculate the zero position heat flux using the HFG millivolt signal and its calibration constant, and begin observing a 5-minute rolling average.

B2.5.2.6 Once a stable heat flux is determined, adjust the temperature setting as necessary, and restart the 5-minute rolling average. Repeat this process until the zero-position heat flux is within the appropriate range (table B2-1).

B2.5.3 System Upset Check

Prior to testing, a system upset check must be completed once the zero-position heat flux is determined to be stable and within tolerance. The heat flux must return to the zero-position range, as specified in table B2-1 during this check.

B2.5.3.1 Raise the pilot burner to the standby position.

B2.5.3.2 Pull the sliding platform out to its stop and hold open for 30 seconds (simulated material load time).

B2.5.3.3 After 30 seconds, close the sliding platform completely.

B2.5.3.4 Lower the pilot burner into the test position.

B2.5.3.5 Allow the process-controller temperature to return to its original setpoint (± 1°F).

B2.5.3.6 Begin the 5-minute heat flux rolling average calculation.

B2.5.3.7 After the 5-minute average heat flux is determined to be correct (zero position), proceed to the next step, or make adjusts as necessary and repeat (refer to table B2-1).

B2.5.3.8 Raise the pilot burner to the standby position, then, using caution because it may be very hot, open the drawer and remove the HFG calibration assembly.

NOTE: It is acceptable to leave the assembly at the left end of the chamber during material testing if the HFG is protected and cooling water is flowing to prevent damage to the sensor.

B2.5.4 Three-Position Check

A three-position heat-flux check is required whenever the radiant panel is replaced or whenever the HFG has been recalibrated or replaced. To ensure the panel is operating correctly, there must be a drop in observed heat flux as the distance from the zero position increases (position

#2). Allow the HFG to reach steady state at each position before recording the heat flux. The distance between the centerlines of each of the three positions is 2 ± 0.0625 inches (50.8 ± 1.6 mm). As the holder is being moved, make sure to place high-temperature boards to the right of the holder to prevent heat loss. For daily testing, a heat flux check in the zero position is sufficient.

B2.5.4.1 Conduct “Zero Position Calibration” (see section B2.5.2)

B2.5.4.2 Conduct “System Upset Check” (see section B2.5.3)

B2.5.4.3 Raise the pilot burner to the standby position, open the drawer, and move the calibration assembly to position #1. Move insulation boards to the left. Cover any gap that opened to the right side of the calibration assembly.

B2.5.4.4 Close the drawer and lower the pilot burner into test position. Calculate the 5-minute heat-flux rolling average to confirm heat flux is within range for position #1 (refer to table B2-1).

B2.5.4.5 Raise the pilot burner to the standby position, open the drawer, and move the calibration assembly to position #2 (refer to table B2-1). Move insulation boards to the left. Cover any gap that opened to the right side of the calibration assembly.

B2.5.4.6 Close the drawer and lower the pilot burner into test position. Calculate the 5-minute heat-flux rolling average to confirm heat flux is within range for position #2.

B2.6 Test Procedure

B2.6.1 General Information

Once calibration is verified, testing can begin. If testing is not conducted for a period of time exceeding 30 minutes, the HFG calibration assembly must be installed and allowed to stabilize for a minimum of 5 minutes, followed by a “System Upset Check” (section B2.5.3). The heat flux must return to the zero-position range, as specified in table B2-1, during this check.

It is extremely important that each test must be carefully observed to determine flame propagation and after-flame accurately. Flame propagation is not a determination of burn length made after the test. Flame propagation can occur without leaving any trace of sample damage.

NOTE: Flame propagation is a measurement of distance, whereas after-flame is a measurement of time. Generally speaking, after-flame may have some flame-propagation characteristics.

The farthest flame-propagation distance to the left of the centerline of the pilot burner must be identified considering the following criteria:

1. Flame propagation left of the centerline of the pilot burner while the burner is in the test position

2. Flashing on the sample that occurs left of the centerline of the pilot burner while the burner is in the test position
3. Flame propagation or flashing on the sample that occurs left of the centerline of the pilot burner once the burner is raised to the standby position

B2.6.2 Sample Ventilation Slit

With all film coverings, make a slit on the top surface of the film cover approximately 2.5 ± 0.5 inches (64 ± 13 mm) long, front to back relative to test chamber, and centered approximately 4 ± 0.5 inches (102 ± 13 mm) from the left flange of the retaining frame. The slit is for test purposes only to allow ventilation of gases during testing. This is not a requirement for the installed insulation.

B2.6.3 Test Sequence

B2.6.3.1 Conduct “Zero Position Calibration” (see section B2.5.2)

B2.6.3.2 Conduct “System Upset Check” (see section B2.5.3)

B2.6.3.3 Stack up insulation boards inside the drawer so the top surface of the test sample will be level with the bottom surface of the drawer upper flange when placed inside. The rest of the inside of the drawer should be completely covered with insulation boards so no convective airflow can pass through.

B2.6.3.4 Ignite the pilot burner and keep it in the standby position. Verify that the flame is the correct length.

B2.6.3.5 Open the drawer and place the test sample in the sliding platform. Place the retaining frame over the test sample, if required (see figure B2-5).

B2.6.3.6 Immediately push the sliding platform into the chamber (within 3 seconds or less).

B2.6.3.7 Within 1 second or less, bring the pilot burner flame into contact with the center of the sample at the zero position, and simultaneously start the timer.

B2.6.3.8 After an ignition time of 15 seconds or, in some cases, 30 seconds, quickly lift the burner flame to the standby position within 1 second or less.

B2.6.3.9 Open the drawer, take measurements, and record data, then remove the test sample. Continue testing as necessary. To avoid excessive heat loss, keep the drawer closed when not loading, measuring, or unloading samples.

B2.6.3.10 When test series is complete, conduct system “Recheck” to verify posttest heat flux is within range. If not within range, previous test data are invalid (refer to table B2-1).

B2.6.4 System Recheck Procedure

B2.6.4.1 Install the HFG fixture at the zero position. Place a sheet of noncombustible material on top of the sliding platform adjacent to the calorimeter fixture (to the left) to prevent heat loss during calibration. All gaps within the drawer opening that could allow air to flow through must be covered.

B2.6.4.2 Ensure the HFG surface is clean, properly aligned, and that cooling water is flowing. Close the sliding platform.

B2.6.4.3 The pilot burner must be off and in the down position (test position).

B2.6.4.4 Allow the system to stabilize for 25 minutes.

B2.6.4.5 After 25 minutes, calculate the zero-position “Recheck” heat flux using the HFG millivolt signal and its calibration constant, and begin a 5-minute rolling average.

B2.6.4.6 After 5 minutes (no adjustments permitted), verify heat flux is within the “Recheck” range (table B2-1).

B2.6.4.7 You may continue material testing after a “Recheck,” or shut down the system and allow the apparatus to cool to ambient conditions if testing has been completed.

B2.7 Report

B2.7.1 Setpoint Temperature

Record the temperature set point for the radiant panel power controller.

B2.7.2 Zero Position Calibration

Record the 5-minute average heat-flux value (BTU/ft^2-sec or W/cm^2).

B2.7.3 Chamber Temperature

Report the pretest chamber temperature after calibration.

B2.7.4 System Recheck

Record the 5-minute average heat-flux value (BTU/ft^2*sec).

B2.7.5 Material Identification

Fully identify and describe the test sample (e.g., width, length, thickness).

B2.7.6 Ignition Time

Report the ignition time in seconds for each sample tested (15 or 30 seconds).

B2.7.7 After-Flame

Report the after-flame time in seconds for each sample tested.

B2.7.8 Flame Propagation

Report the flame propagation length for each sample tested.

B2.7.9 Notes/Comments

Report any occurrences of shrinkage, melting, glowing, swelling, flashing, or char.

B2.7.10 Pass/Fail

Report the total number of materials tested and total number of materials that passed.

B2.8 Requirements

B2.8.1 Quantity of Samples

A minimum of three samples must be tested, and 80 percent or greater must pass both criteria specified in B2.8.2 and B2.8.3. An example is shown in table B2-2.

Table B2-2. Quantity of samples that must pass for a given number tested

Total Samples Tested	Must Pass	%
3	3	100%
4	4	100%
5	4	80%
6	5	83%
7	6	86%
8	7	88%
9	8	89%
10	8	80%
11	9	82%
12	10	83%

B2.8.2 After-Flame

The after-flame time, after removal of the pilot burner flame, must not exceed 3 seconds.

B2.8.3 Flame Propagation

There must be no flame propagation or flashing beyond 2 inches (50.8 mm) measured to the left of the centerline of the pilot burner.

Chapter B3
Vertical Flame Propagation Test Method for Composite Structure

B3.1 Scope

This test method can be used to evaluate the flame-propagation potential of extensively used materials located in inaccessible areas of a passenger airplane. Extensively used materials include nonmetallic structure and skin, ducts, wire insulation, and other materials not included in the small parts definition.

B3.2 Definitions

B3.2.1 Burn Length

The burn length is the posttest measurement of the length of the burned surface of the test sample, parallel to the long edge (12-inch dimension). For the purposes of this test method, the burn length is considered to be the length where the outermost layer of the material has been burned away, breached, or opened, indicating that volatiles have escaped the material at that location and could have been ignited. An example of a burn area measurement is displayed in figure B3-1.

It can be measured from below the point of ignition if the sample burns down and up.

B3.2.2 After-Flame Time

The after-flame time is defined as the time, in seconds, that visible flaming is observed on the test-sample surface after the removal of the ribbon burner flame.

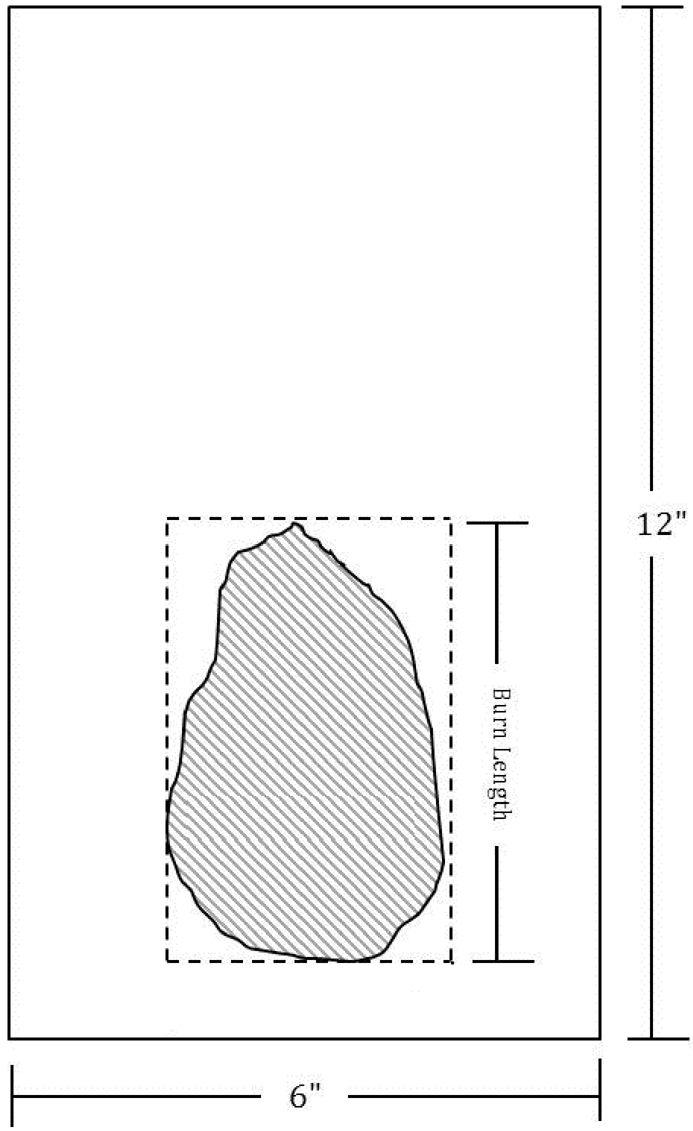


Figure B3-1. Schematic of the burned area, indicating the burn length

B3.3 Apparatus

B3.3.1 Test Apparatus

The test apparatus is the vertical flame propagation (VFP) test device, as described in appendix N and displayed in figure B3-2. The sample type (i.e., composite skin, duct, or wire) will dictate the exact configuration and operation of the device. See Advisory Circulars for detailed instructions and means of compliance (MOC) for more test information.

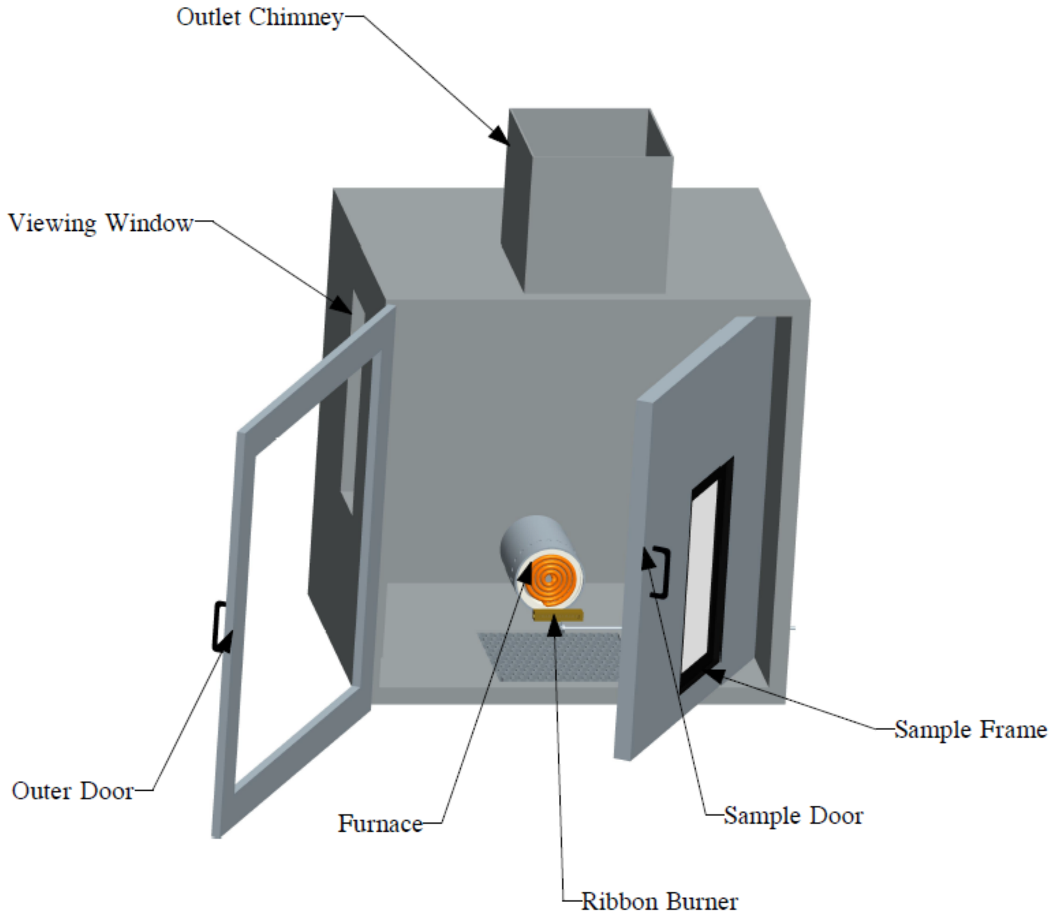


Figure B3-2. Schematic of the VFP test apparatus

B3.3.2 Instrumentation

B3.3.2.1 Data-Acquisition System

The data to be acquired electronically are the thermocouple temperature at the center of the inner back wall of the chamber and the power provided to the furnace (watts). Current (amps) and resistance (ohms) shall also be monitored/recorded to track the health of the furnace coil. Additional accommodations shall be made for the pre-test input of a sample name/number, the post-test record of the burn length, and after-flame time.

B3.3.2.2 Timing Device

A stopwatch or other device, accurate to within ±1 second per 8 hours (±3 sec per day), must be used to measure the time of application of the ribbon burner flame and any after-flame time.

B3.3.2.3 Anemometer

A handheld, 4-inch outer diameter vane-type anemometer should be used to measure the flow of air through the hood of the test apparatus. The anemometer is held at each corner, consuming one-fourth of the exhaust hood to measure each area.

B3.3.2.4 Test Room

The test apparatus shall be located in a suitable room to reduce or eliminate the possibility of test fluctuation due to air movement. The test room should have a minimum floor area of 10 by 10 feet.

B3.3.2.5 Room Ventilation

The room in which the VFP apparatus is situated must have an exhaust system capable of removing the products of combustion expelled during the test.

B3.3.2.6 Thermocouple

A surface-mounted Type K thermocouple no greater than 24 gauge, is placed on the center of the inner back wall of the test chamber. This is done to measure the internal chamber temperature for reference only.

B3.3.2.7 Mass Flow Controllers

The air and fuel flow to the ribbon burner must be precisely measured and controlled using a mass flow controller. The air and fuel flow is measured in standard liters per minute (SLPM) units. They must be calibrated to the standard temperature and pressure conditions of 25°C and 14.6959 PSIA.

B3.4 Test Samples

B3.4.1 Sample Preparation

Test samples representing the component to be evaluated shall be constructed of the identical composite layup as the component used in service.

B3.4.2 Sample Number

A minimum of three samples for each component or design configuration must be prepared for testing.

B3.4.3 Sample Size

The samples to be tested will measure 6 inches wide by 12 inches long (+0/-0.125 inch), with the thickness representing the actual thickness of the component or design configuration to be tested. If the component cannot be made in a flat sheet configuration (i.e., some ducts and wires), then alternative sample sizes will be used. See Advisory Circular for more information on non-flat sheet test-sample configurations.

B3.4.4 Sample Orientation

The samples are mounted so the 12-inch dimension is the vertical dimension.

B3.4.5 Sample Coatings

If a finish coating or other surface treatment will be used on the component in service, additional test samples must also be prepared and tested with this treatment to ensure the surface treatment does not adversely affect sample performance.

B3.4.6 Sample Conditioning

The samples will be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

B3.5 Preparation of Apparatus

B3.5.1 Furnace Alignment

B3.5.1.1 Furnace Orientation

With the furnace installed, the heating element must be positioned so that the coil loops are at the 12 o'clock position, as shown in figure B3-3.

B3.5.1.2 Furnace to Sample Distance

Measure the distance from the surface of the coil heating element to the inner surface of the sample holder where the test-sample surface would be located. The distance should be 3 inches (76.2 mm). See figure B3-4.

B3.5.1.3 Furnace Height

Measure the vertical height from the center of the coil heating element to the bottom inner surface of the sample frame where the bottom edge of the test sample would be located. The distance should be 1.5625 inches (39.6 mm). See figure B3-5.

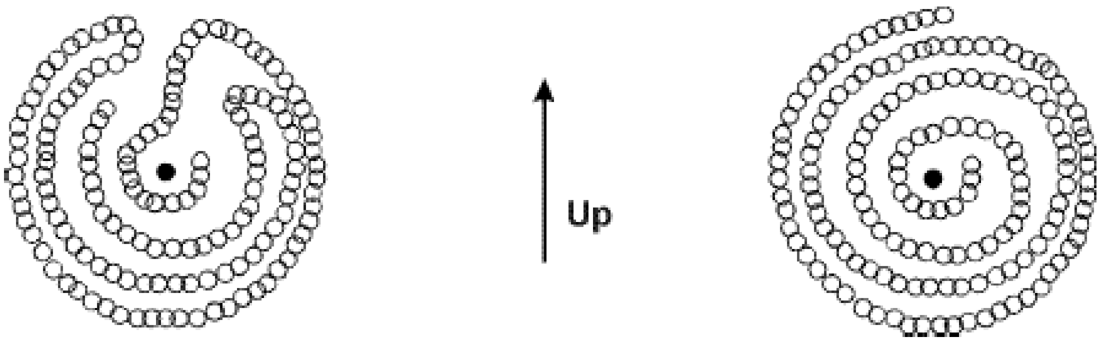


Figure B3-3. Furnace Coil Orientation

B3.5.2 Ribbon Burner Alignment

B3.5.2.1 Push the ribbon burner into the test position.

B3.5.2.2 The vertical height of the ribbon burner flame is 1.125 inches (28.7 mm) from the bottom inner surface of the sample frame. See figure B3-4.

B3.5.2.3 The lateral positioning of the ribbon burner will be such that the vertical centerline is aligned with the vertical centerline of the furnace coil heating element. The distance from the face of the ribbon burner to the inner surface of the sample frame should be 0.5 inch (12.7mm). See figure B3-5.

B3.5.3 Ribbon Burner Flame Adjustment

B3.5.3.1 Methane/Air

B3.5.3.3.1 Methane and air pressure should be set to 30 psig unless otherwise stated by the mass flow controller's requirements. Adjust the methane and air flow rates to 0.66 SLPM/3.6 SLPM respectively. These rates are set for a mass flow controller that is calibrated to the standard temperature and pressure conditions of 25°C and 14.6959 PSIA.

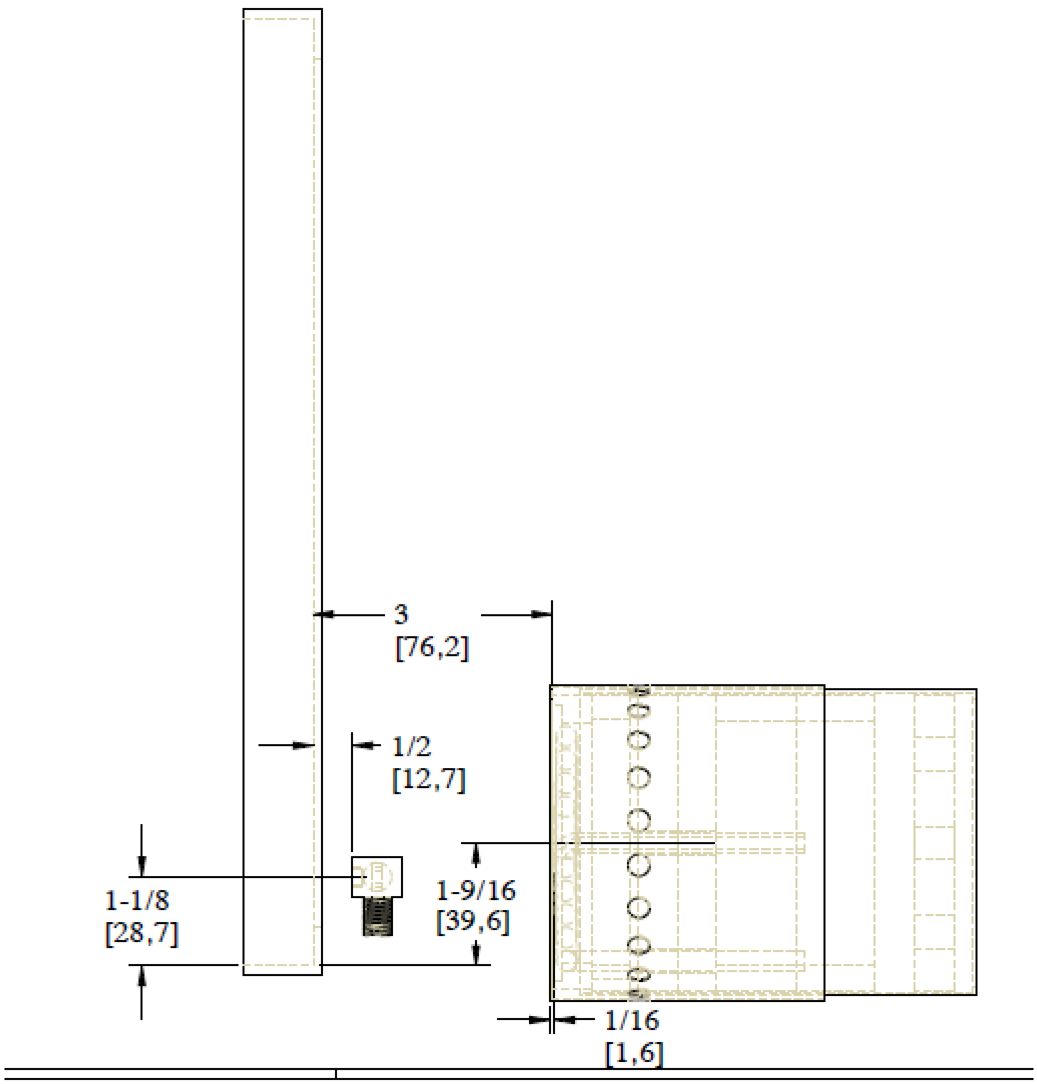


Figure B3-4. Furnace and pilot flame dimensions relative to the sample frame

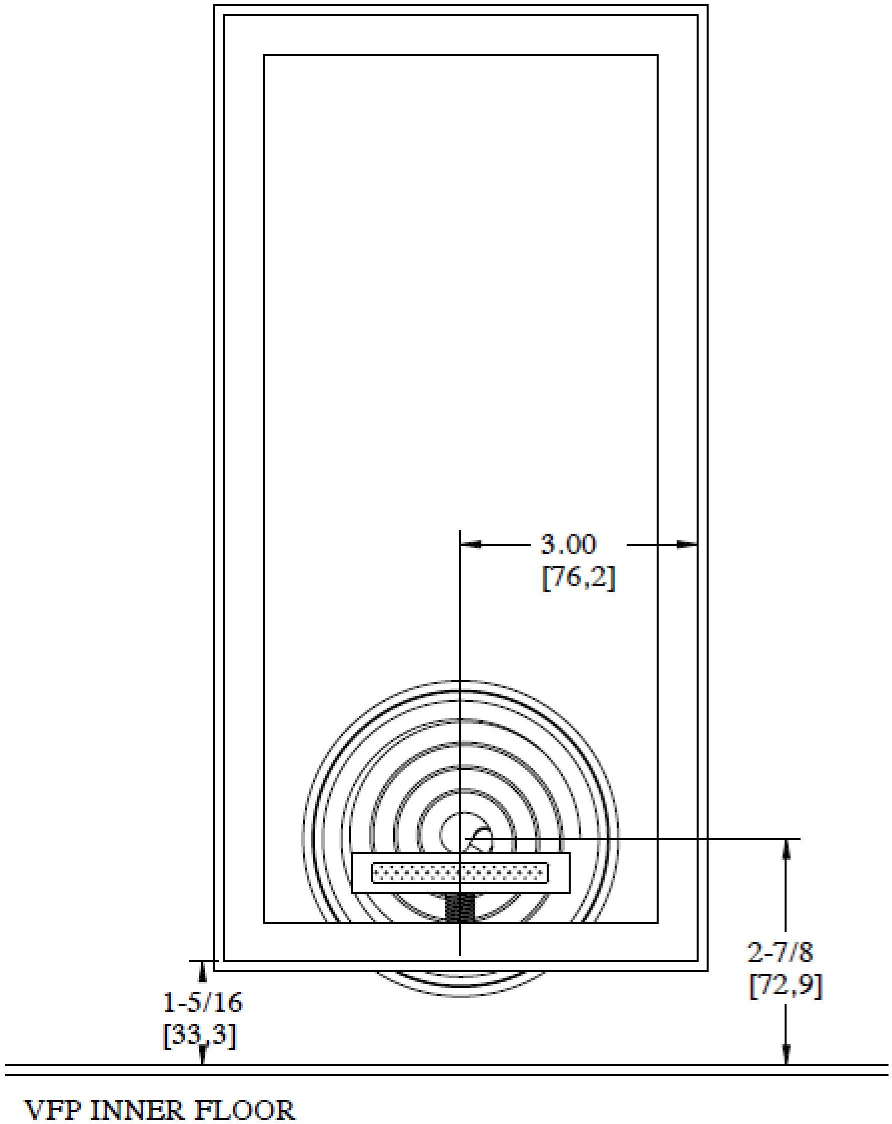


Figure B3-5. Lateral positioning of the pilot burner relative to the centerlines of the heater coil and sample frame

B3.6 Apparatus Pre-Heat Procedure

B3.6.1 Switch on AC voltage.

B3.6.2 Begin data collection.

B3.6.3 Adjust AC voltage to achieve 706 watts over a 5-minute average.

B3.6.4 Ensure that the exhaust fan that will run during testing is switched on.

B3.6.5 Allow chamber to stabilize for 45 minutes or when the internal chamber temperature stabilizes to 71 °C.

B3.6.6 Once the chamber has stabilized, place the vane anemometer at the prescribed locations of the VFP exhaust hood. This is shown as the two marked “x” in figure B3-6.

B3.6.7 Record the average flow velocity through the anemometer.

B3.6.8 Typical flow rates achieved are approximately 135 ± 10 ft/min with a stable chamber and exhaust fan off. The flow rates achieved are approximately 145 ± 10 ft/min with the exhaust fan on.

B3.6.9 Remove the anemometer.

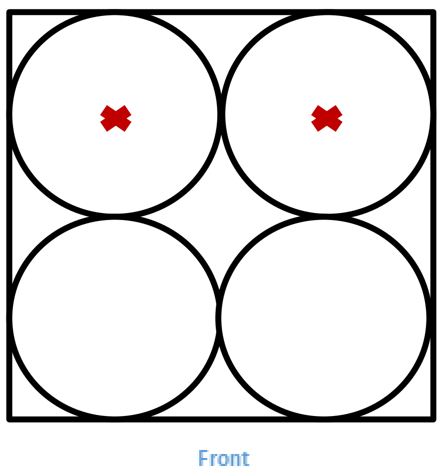


Figure B3-6. Locations of the velocity measurement of the VFP exhaust hood

B3.7 Test Procedure

B3.7.1 Open outer door.

B3.7.2 Open sample door.

B3.7.3 Initiate flow of premixed methane to air mixture to ribbon burner.

B3.7.4 Ignite ribbon burner.

B3.7.5 Place test sample in sample holder with the face to be tested toward the radiant heater.

B3.7.6 Secure test sample. The sample door is still open and should not be closed yet.

B3.7.7 Push ribbon burner into position.

B3.7.8 Reset stopwatch to 0, and prepare to start timing upon sample door closing.

B3.7.9 Close sample door, begin stopwatch count.

B3.7.10 Close outer door to protect user.

B3.7.11 Pull the ribbon burner back into the standby position at the appropriate flame impingement time for the test being performed. (August 2018 = 30-second impingement time). Do not stop the timer yet.

B3.7.12 Monitor sample flame propagation via viewing windows or video monitor.

B3.7.13 Stop timer when all flaming on sample surface ceases.

B3.7.14 Record after flame time as the time at extinguishment minus the flame impingement time.

B3.7.15 Open door, remove sample, and place under fume hood until off-gassing ceases.

B3.7.15.1 If continuing to test, place next sample in sample holder and repeat.

B3.7.15.2 If testing is complete, place heat-resistant board back into the sample holder, replace outer retainer ring and clamp into place, and close sample door.

B3.8 Burn Length Measurement Procedure

B3.8.1 Wait until sample has cooled to the touch and is no longer off-gassing.

B3.8.2 Use mild detergent cleaner and a cloth to wipe away sooted areas of the sample face.

B3.8.3 Burn length measurement. See figure B3-1 for more detail.

B3.8.3.1 Determine the boundaries of the burned length.

B3.8.3.2 For the purposes of this test method, burn areas are considered to be areas where the outermost layer of the material has been burned away, breached, or opened, indicating that volatiles have escaped the material at that location and could have ignited.

B3.8.3.3 Sooted or discolored areas are not considered part of the burned area.

B3.8.3.4 Draw lines parallel to the horizontal (6-inch) dimension of the sample that include the extent of the burned length.

B3.8.3.5 The burn length is the vertical distance between these drawn lines.

B3.9 Report

B3.9.1 Report a complete description of the material(s) being tested, including manufacturer, composition, and trade name.

B3.9.2 For each of the three samples tested, report the after-flame time and burn length.

B3.9.3 Record any observations regarding the behavior of the test sample during the test, such as popping, smoke, backside flaming, and the time of the event.

B3.9.4 Provide a record of the test apparatus thermocouple stability measurement and measured test apparatus hood flow velocity.

B3.10 Requirements

B3.10.1 None of the three samples tested shall burn for extended periods of time.

B3.10.2 None of the three samples shall have a burn length greater than 3.5 inches (89 mm).

B3.10.3 If one or more of the samples fail to meet the above requirements, it is possible to run additional recovery tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5=80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Chapter B4
Vertical Flame Propagation Test Method for Ducting

B4.1 Scope

This test method can be used to evaluate the flame-propagation potential of extensively-used ducting materials located in inaccessible areas of a transport category airplanes.

B4.2 Definitions

B4.2.1 Burn Length

The burn length is the post-test measurement of the length of the burned surface of the test sample, parallel to the long edge (12-inch dimension). For the purposes of this test method, the burn length is considered to be the length at which the outermost layer of the material has been burned away, breached, or opened, indicating that volatiles have escaped the material at that location and could have been ignited. An example of a burn area measurement is displayed in figure B4-1.

It can be measured from below the point of ignition if the sample burns down and up.

B4.2.2 After-Flame Time

The after-flame time is defined as the time, in seconds, that visible flaming is observed on the test-sample surface after the removal of the ribbon burner flame.

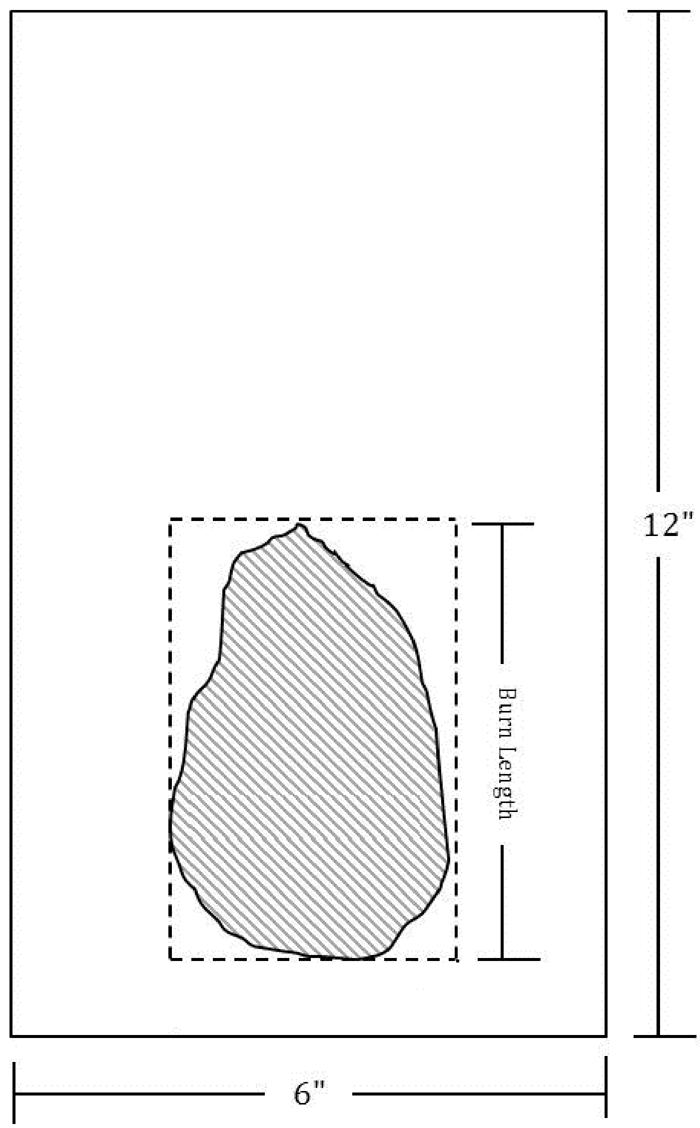


Figure B4-1. Schematic of the burned area, indicating the burn length

B4.3 Apparatus

B4.3.1 Test Apparatus

The test apparatus is the vertical flame propagation (VFP test device, as described in appendix N and displayed in figure B4-2. The sample type (i.e., composite skin, duct, or wire) will dictate the exact configuration and operation of the device. See Advisory Circular for detailed instructions and means of compliance (MOCs) for more test information.

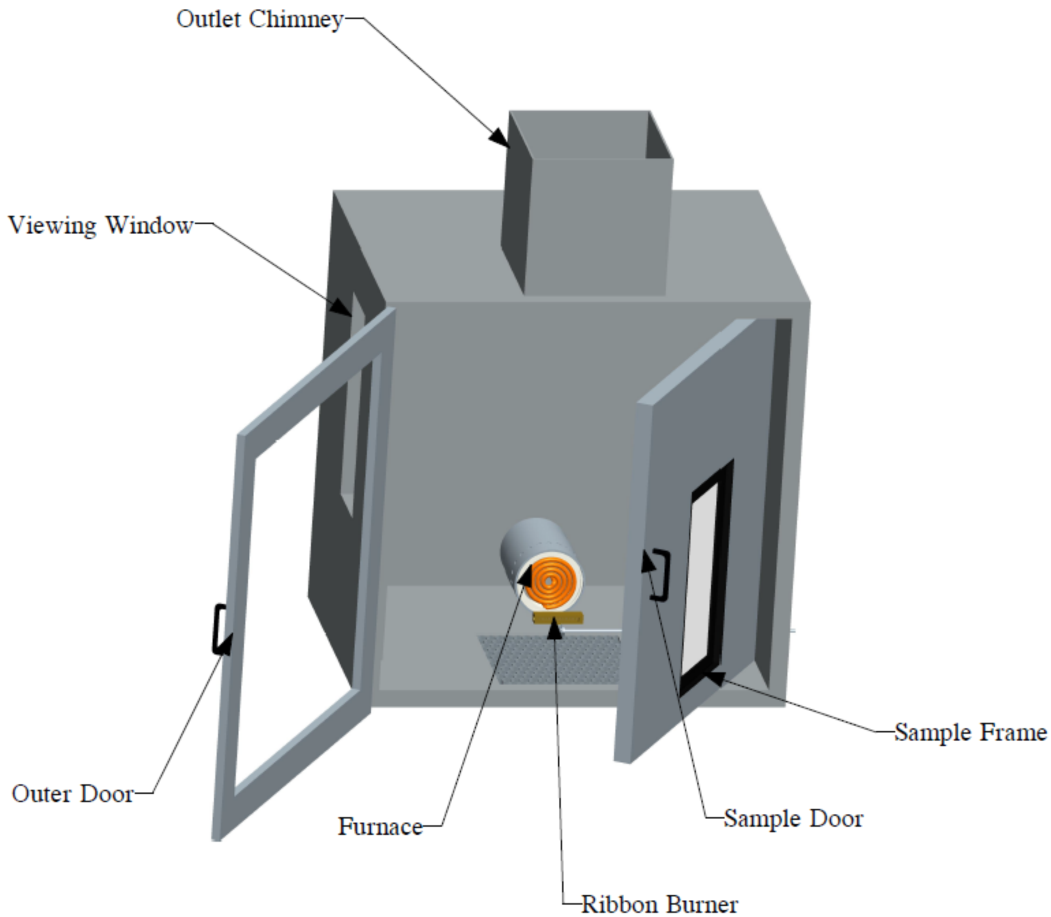


Figure B4-2. Schematic of the vertical flame propagation test apparatus

B4.3.2 Instrumentation

B4.3.2.1 Data-Acquisition System

The data to be acquired electronically is the thermocouple temperature on the inner back wall of the chamber and the power provided to the furnace (watts). Current (amps) and resistance (ohms) shall also be monitored/recorded to track health of the furnace coil. Additional accommodations shall be made for the pre-test input of a sample name/number, the post-test record of the burn length and after-flame time.

B4.3.2.2 Timing Device

A stopwatch or other device, accurate to within ±1 second per 8 hours (±3 sec per day), must be used to measure the time of application of the pilot flame and any after-flame time.

B4.3.2.3 Anemometer

A handheld, 4-inch outer diameter vane-type anemometer should be used to measure the flow of air through the hood of the test apparatus. The anemometer is held at each corner, consuming one-fourth of the exhaust hood to measure each area.

B4.3.2.4 Test Room

The test apparatus shall be located in a suitable room to reduce or eliminate the possibility of test fluctuation due to air movement. The test room should have a minimum floor area of 10 by 10 feet.

B4.3.2.5 Room Ventilation

The room in which the VFP apparatus is situated must have an exhaust system capable of removing the products of combustion expelled during the test.

B4.3.2.6 Thermocouple

A surface-mounted Type K thermocouple, no greater than 24 gauge, is placed on the center of the inner back wall of the test chamber. This is done to measure the internal chamber temperature for reference only.

B4.3.2.7 Mass Flow Controllers

The air and fuel flow to the ribbon burner must be precisely measured and controlled using a mass flow controller. The air and fuel flow is measured using standard liters per minute (SLPM). They must be calibrated to the standard temperature and pressure conditions of 25°C and 14.6959 PSIA.

B4.4 Test Samples

B4.4.1 Sample Preparation

Test samples representing the duct to be evaluated shall be constructed of the identical composition duct used in service. If the duct is constructed of multiple plies with varying orientations, then the duct sample shall be constructed with an identical ply orientation.

B4.4.2 Sample Number

A minimum of three samples for each component or design configuration must be prepared for testing.

B4.4.3 Sample Size

The samples to be tested will measure 12 inches long (+0/-0.125 inch), with the thickness representing the actual thickness of the component or design configuration to be tested. If the duct cannot be made in a flat sheet configuration, then alternative sample sizes will be used. See Advisory Circular for more information on non-flat sheet test-sample configurations.

B4.4.4 Sample Orientation

The samples are mounted such that the 12-inch dimension is the vertical dimension. If a unidirectional ply is on the outermost face, then the fibers should be aligned with the 12-inch dimension.

B4.4.5 Sample Coatings

If a finish coating or other surface treatment will be used on the component in service, additional test samples must also be prepared and tested with this treatment to ensure the surface treatment does not adversely affect sample performance.

B4.4.6 Sample Conditioning

The samples will be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

B4.5 Preparation of Apparatus

B4.5.1 Furnace Alignment

B4.5.1.1 Furnace Orientation

With the furnace installed, the heating element must be positioned so that the coil loops are at the 12 o'clock position, as shown in figure B4-3.

B4.5.1.2 Furnace to Sample Distance

Measure the distance from the surface of the coil heating element to the inner surface of the sample holder, where the test-sample surface would be located. The distance should be 3 inches (76.2 mm). See figure B4-4.

B4.5.1.3 Furnace Height

Measure the vertical height from the center of the coil heating element to the bottom inner surface of the sample frame, where the bottom edge of the test sample would be located. The distance should be 1.5625 inches (39.6 mm). See figure B4-4.

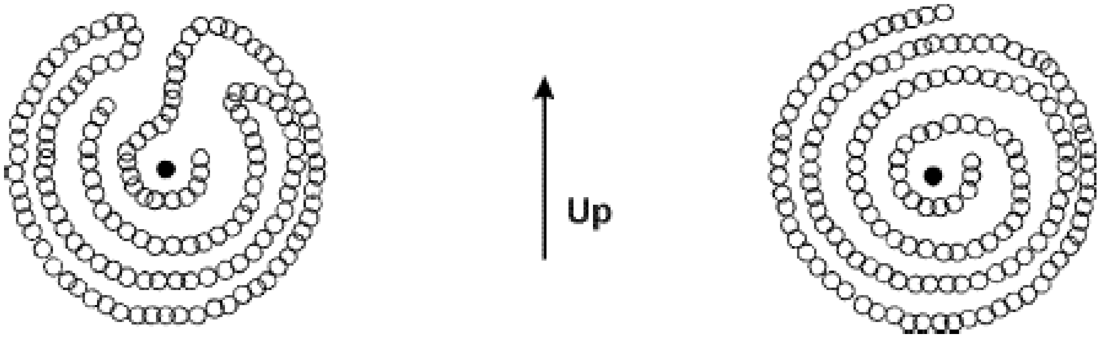


Figure B4-3. Furnace Coil Orientation

B4.5.2 Ribbon Burner Alignment

B4.5.2.1 Push the ribbon burner into the test position.

B4.5.2.2 The vertical height of the ribbon burner flame is 1.125 inches (28.7 mm) from the bottom inner surface of the sample frame. See figure B4-4.

B4.5.2.3 The lateral positioning of the ribbon burner will be such that the vertical centerline is aligned with the vertical centerline of the furnace coil heating element. The distance from the face of the ribbon burner to the inner surface of the sample frame should be 0.5 inch (12.7mm). See figure B4-5.

B4.5.3 Ribbon Burner Flame Adjustment

B4.5.3.1 Methane/Air

B4.5.3.1.1 Methane and air pressure should be set to 30 psig unless otherwise stated by the mass flow controller's requirements. Adjust the methane and air flow rates to 0.66 SLPM/3.6 SLPM, respectively. These rates are set for a mass flow controller that is calibrated to the standard temperature and pressure conditions of 25°C and 14.6959 PSIA.

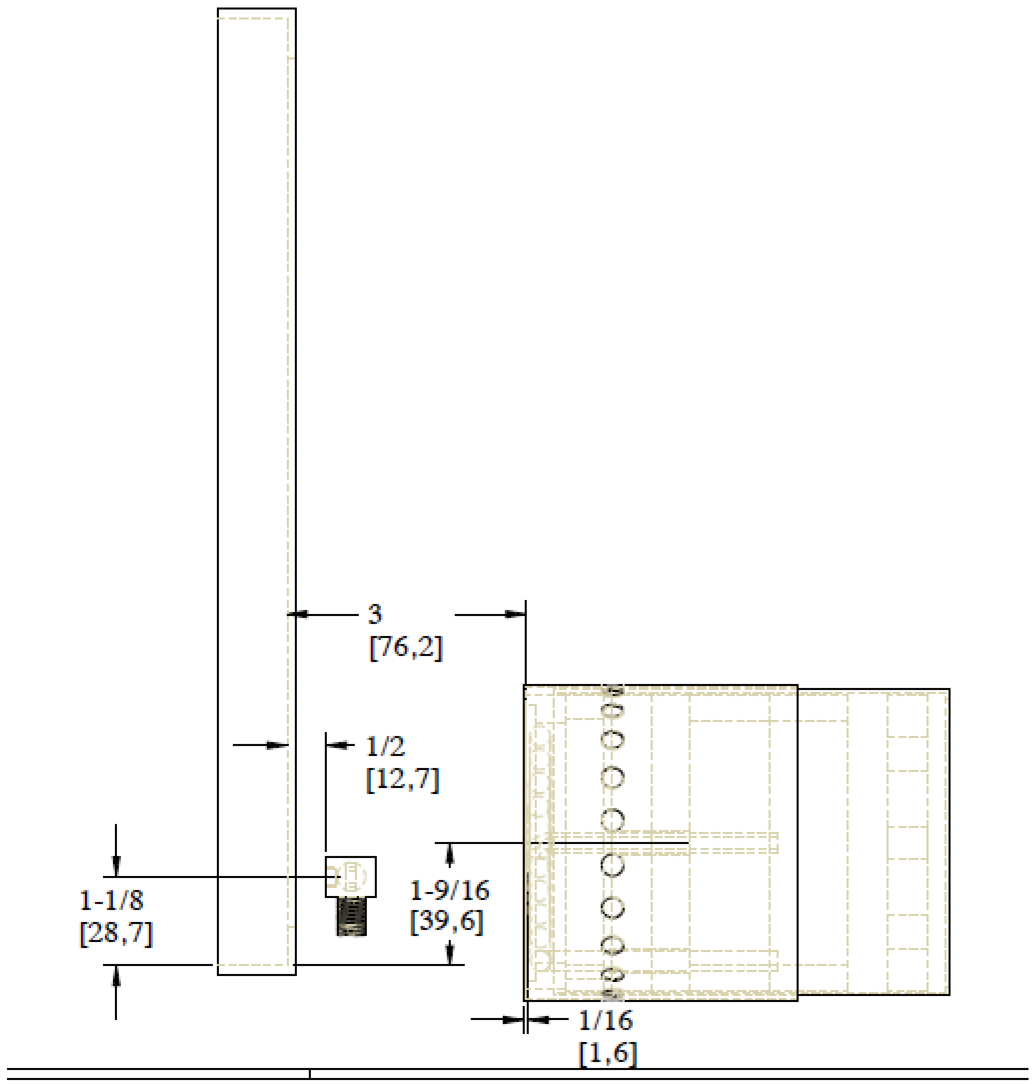


Figure B4-4. Furnace and pilot flame dimensions relative to the sample frame

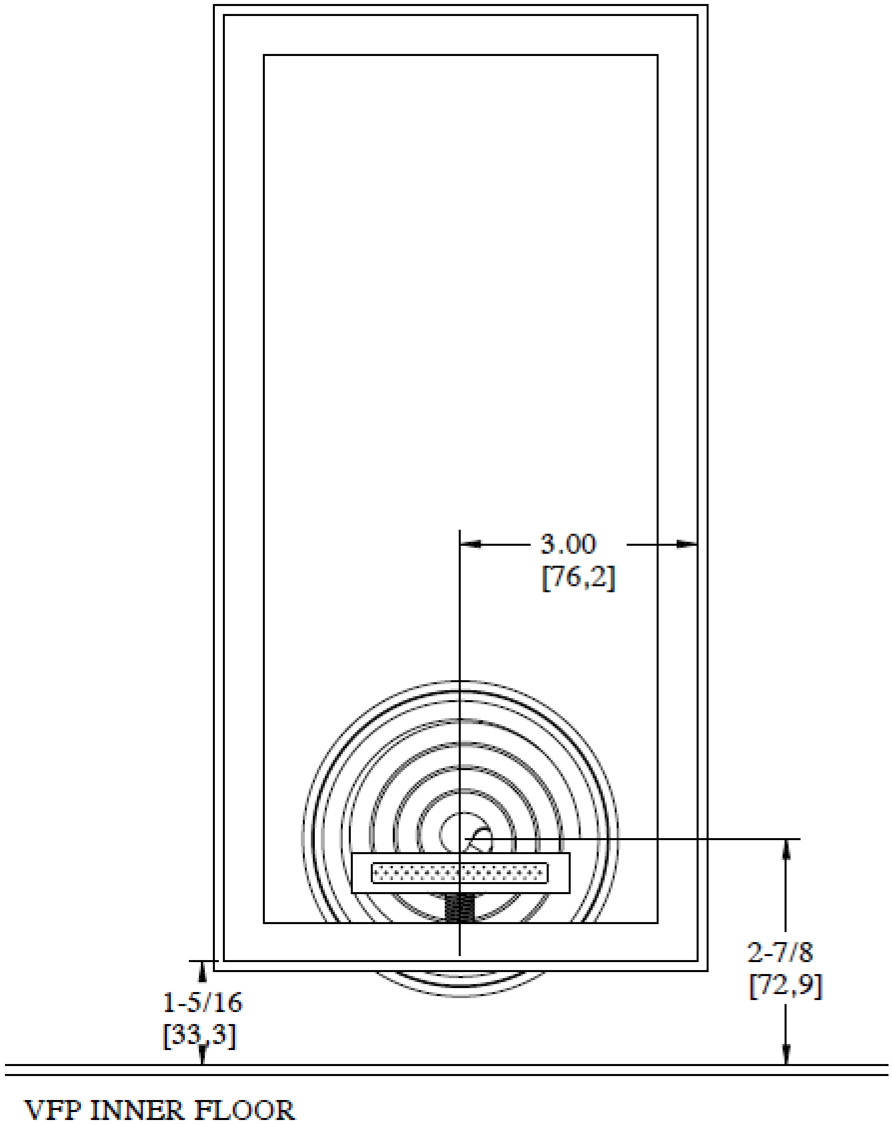


Figure B4-5. Lateral positioning of the pilot burner relative to the centerlines of the heater coil and sample frame

B4.6 Apparatus Pre-Heat Procedure

B4.6.1 Switch on AC voltage.

B4.6.2 Begin data collection.

B4.6.3 Adjust AC voltage to achieve 706 watts over a 5-minute average.

B4.6.4 Ensure exhaust fan that will be used during testing is switched on.

B4.6.5 Allow chamber to stabilize for 45 minutes or when the internal chamber temperature stabilizes to 71°C.

B4.6.6 Once the chamber has stabilized, place the vane anemometer at the prescribed locations of the VFP exhaust hood. This is shown as the two marked “x” in figure B4-6.

B4.6.7 Record the average flow velocity through the anemometer.

B4.6.8 Typical flow rates achieved are approximately 135 ± 10 ft/min with a stable chamber and exhaust fan off. The flow rates achieved are approximately 145 ± 10 ft/min with the exhaust fan on.

B4.6.9 Remove the anemometer.

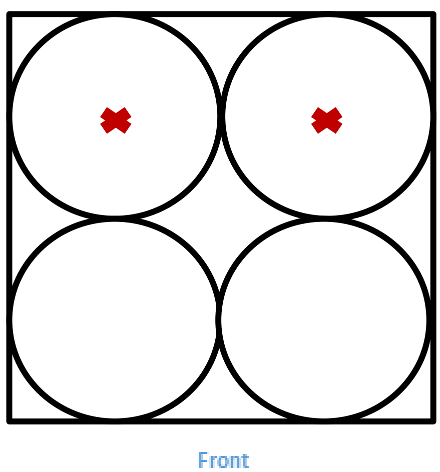


Figure B4-6. Locations of the velocity measurement of the VFP exhaust hood

B4.7 Test Procedure

B4.7.1 Open outer door.

B4.7.2 Open sample door.

B4.7.3 Initiate flow of premixed propane or methane to air mixture to ribbon burner.

B4.7.4 Ignite ribbon burner.

B4.7.5 Place test sample in sample holder with the face to be tested toward the radiant heater.

B4.7.6 Secure test sample.

B4.7.7 Push ribbon burner into position.

B4.7.8 Reset stopwatch to zero and prepare to start timing upon sample door closing.

B4.7.9 Close sample door, begin stopwatch count.

B4.7.10 Close outer door to protect user.

B4.7.11 Pull the ribbon burner back into the standby position at the appropriate flame impingement time for the test being performed. (August 2018 = 30 second impingement time). Do not stop the timer yet.

B4.7.12 Monitor sample flame propagation via viewing windows or video monitor.

B4.7.13 Stop timer when all flaming on sample surface ceases.

B4.7.14 Record after-flame time as the time at extinguishment minus the flame impingement time.

B4.7.15 Open door, remove sample, and place under fume hood until off-gassing ceases.

B4.7.15.1 If continuing to test, place next sample in sample holder and repeat, OR

B4.7.15.2 If testing is complete, place heat-resistant board back into the sample holder, replace outer retainer ring and clamp into place, and close sample door.

B4.8 Burn Area Measurement Procedure

B4.8.1 Wait until sample has cooled to the touch and is no longer off-gassing.

B4.8.2 Use mild detergent cleaner and a cloth to wipe away sooted areas of the sample face.

B4.8.3 Burn length measurement. See figure B3-1 for more detail.

B4.8.3.1 Determine the boundaries of the burned length.

B4.8.3.2 For the purposes of this test method, burn areas are considered to be areas where the outermost layer of the material has been burned away, breached, or opened, indicating that volatiles have escaped the material at that location and could have ignited.

B4.8.3.3 Sooted or discolored areas are not considered part of the burned area.

B4.8.3.4 Draw lines parallel to the horizontal (6-inch) dimension of the sample that include the extent of the burned length.

B4.8.3.5 The burn length is the vertical distance between these drawn lines.

B4.9 Report

B4.9.1 Report a complete description of the material(s) being tested, including manufacturer, composition, and trade name.

B4.9.2 For each of the three samples tested, report the after-flame time and burn length.

B4.9.3 Record any observations regarding the behavior of the test sample during the test, such as popping, smoke, backside flaming, and the time of the event.

B4.9.4 Provide a record of the test apparatus stability thermocouple measurement and measured test apparatus hood flow velocity.

B4.10 Requirements

B4.10.1 None of the three samples tested shall burn for extended periods of time.

B4.10.2 None of the three samples shall have a burn length greater than 3.5 inches (89 mm).

B4.10.3 If one or more of the samples fail to meet the above requirements, it is possible to run additional recovery tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5=80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Chapter B5
Vertical Flame Propagation Test Method for Wire Insulation

B5.1 Scope

This test method can be used to evaluate the flame-propagation potential of extensively used materials located in inaccessible areas of a passenger airplane. Extensively used materials include nonmetallic structure and skin, ducts, wire insulation, and other materials not included in the small parts definition.

B5.2 Definitions

B5.2.1 Burn Length

The burn length is defined as the post-test measurement of the length of the burned surface of the test sample. For the purposes of this test method, the burn area is considered to be the areas where the outermost layer of the material has been burned away, breached, or opened, indicating that volatiles have escaped the material at that location and could have been ignited. The burn length can be measured as the length of wire from below the point of ignition to the edge of the burn. An example of a burn length measurement is displayed in figure B5-1.

B5.2.2 After-Flame Time

The after-flame time is defined as the time, in seconds, that visible flaming is observed on the test-sample surface after the removal of the pilot flame.

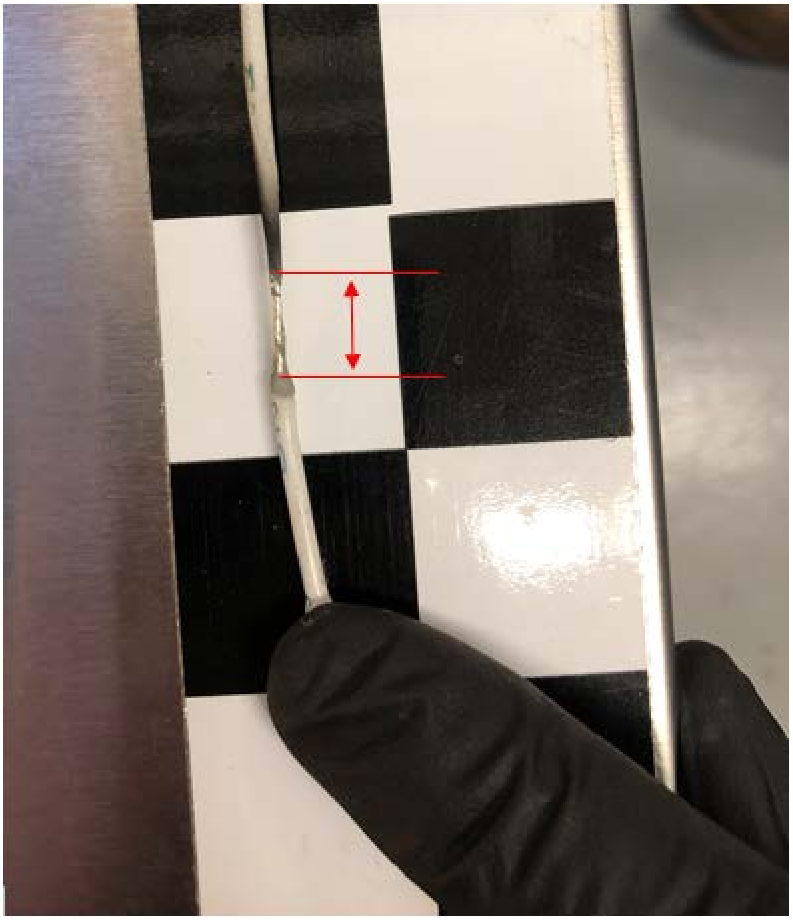


Figure B5-1. Example of the burned length

B5.3 Apparatus

B5.3.1 Test Apparatus

The test apparatus is the Vertical Flame Propagation (VFP) test device, as described in appendix N and displayed in figure B5-2. The sample type (i.e., composite skin, duct, or wire) will dictate the exact configuration and operation of the device. See Advisory Circular for detailed instructions and means of compliance (MOCs) for more test information.

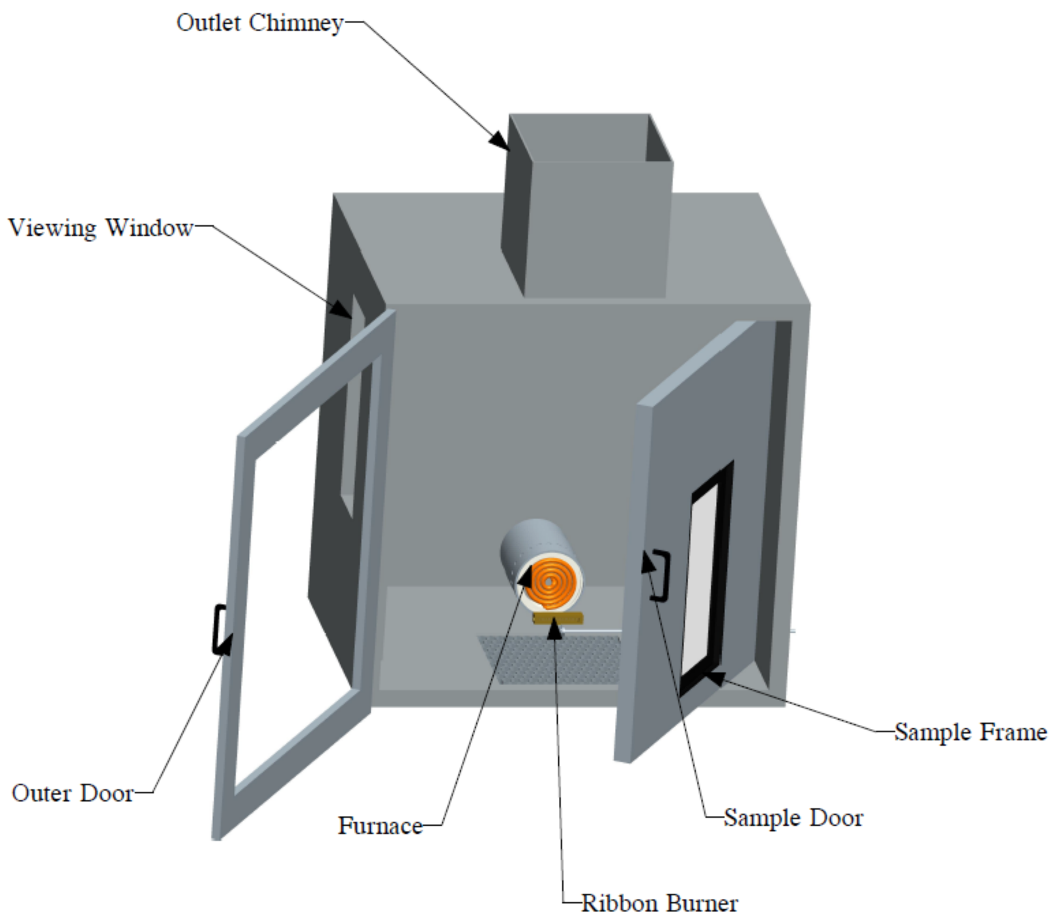


Figure B5-2. Schematic of the vertical flame propagation test apparatus

B5.3.2 Instrumentation

B5.3.2.1 Data-Acquisition System

The data to be acquired electronically is the thermocouple temperature on the inner back wall of the chamber and the power provided to the furnace (watts). Current (amps) and resistance (ohms) shall also be monitored/recorded to track the health of the furnace coil. Additional accommodations shall be made for the pre-test input of a sample name/number, the post-test record of the burn length and after-flame time.

B5.3.2.2 Timing Device

A stopwatch or other device, accurate to within ±1 second per 8 hours (±3 sec per day), must be used to measure the time of application of the pilot flame and any after-flame time.

B5.3.2.3 Anemometer

A handheld 4-inch outer diameter vane-type anemometer should be used to measure the flow of air through the hood of the test apparatus. The anemometer is held at each corner, consuming one-fourth of the exhaust hood to measure each area.

B5.3.2.4 Test Room

The test apparatus shall be located in a suitable room to reduce or eliminate the possibility of test fluctuation due to air movement. The test room should have a minimum floor area of 10 by 10 feet.

B5.3.2.5 Room Ventilation

The room in which the VFP apparatus is situated must have an exhaust system capable of removing the products of combustion expelled during the test.

B5.3.2.6 Thermocouple

A surface mounted Type K thermocouple no larger than 24 gauge is placed on the center of the inner back wall of the test chamber. This is done to measure the internal chamber temperature for reference only.

B5.3.2.7 Mass Flow Controllers

The air and fuel flow to the ribbon burner must be precisely measured and controlled using a mass flow controller. The air and fuel flow is measured using standard liters per minute (SLPM). They must be calibrated to the standard temperature and pressure conditions of 25°C and 14.6959 PSIA.

B5.4 Test Samples

B5.4.1 Sample Preparation

The wire that is being tested must be strung through the sample holder and tightened to be held taut and not loose. Three like wires of the same gauge and composition shall be used per test.

B5.4.2 Sample Number

A minimum of three samples for each component or design configuration must be prepared for testing.

B5.4.3 Sample Size

The wire samples to be tested will be XXXF min/max gauge and strung taut through the sample holder. Three wires of the length of the sample holder will be tested. See Advisory Circular for more information on non-flat sheet test-sample configurations.

B5.5 Preparation of Apparatus

B5.5.1 Furnace Alignment

B5.5.1.1 Furnace Orientation

With the furnace installed, the heating element will be positioned so that the coil loops are at the 12 o'clock position, as shown in figure B5-3.

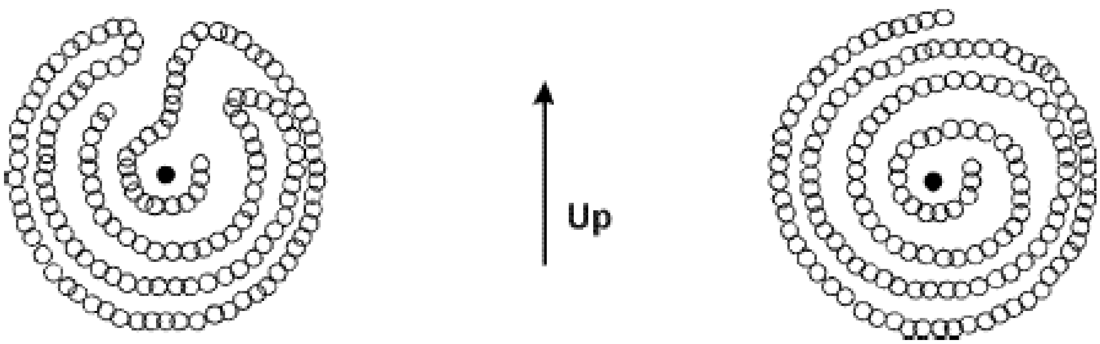


Figure B5-3. Furnace Coil Orientation

B5.5.1.2 Furnace to Sample Distance

Measure the distance from the surface of the coil heating element to the inner surface of the sample holder, where the test-sample surface would be. The distance should be 3 inches (76.2 mm). See figure B3-4.

B5.5.1.3 Furnace Height

Measure the vertical height from the center of the coil heating element to the bottom inner surface of the sample frame, where the bottom edge of the test sample would be. The distance should be 1.5625 inches (39.6 mm). See figure B3-4.

B5.5.2 Ribbon Burner Alignment

B5.5.2.1 Set the ribbon burner to the test position.

B5.5.2.2 The vertical height of the pilot flame is 1.125 inches (28.7 mm) from the bottom inner surface of the sample frame. See figure B3-?.

B5.5.2.3 The lateral positioning of the ribbon burner will be such that the vertical centerline is aligned with the vertical centerline of the furnace coil heating element. The distance from the face of the ribbon burner to the inner surface of the sample frame should be 0.5 inch (12.7mm). See figure B5-5.

B5.5.3 Ribbon Burner Flame Adjustment

B5.5.3.1 Methane/Air

B5.5.3.1.1 Methane and air pressure should be set to 30 psig. Adjust the methane and air flow rates to 0.66 SLPM/3.6 SLPM respectively. These rates are set for a mass flow controller that is calibrated to the standard temperature and pressure conditions of 25°C and 14.6959 PSIA.

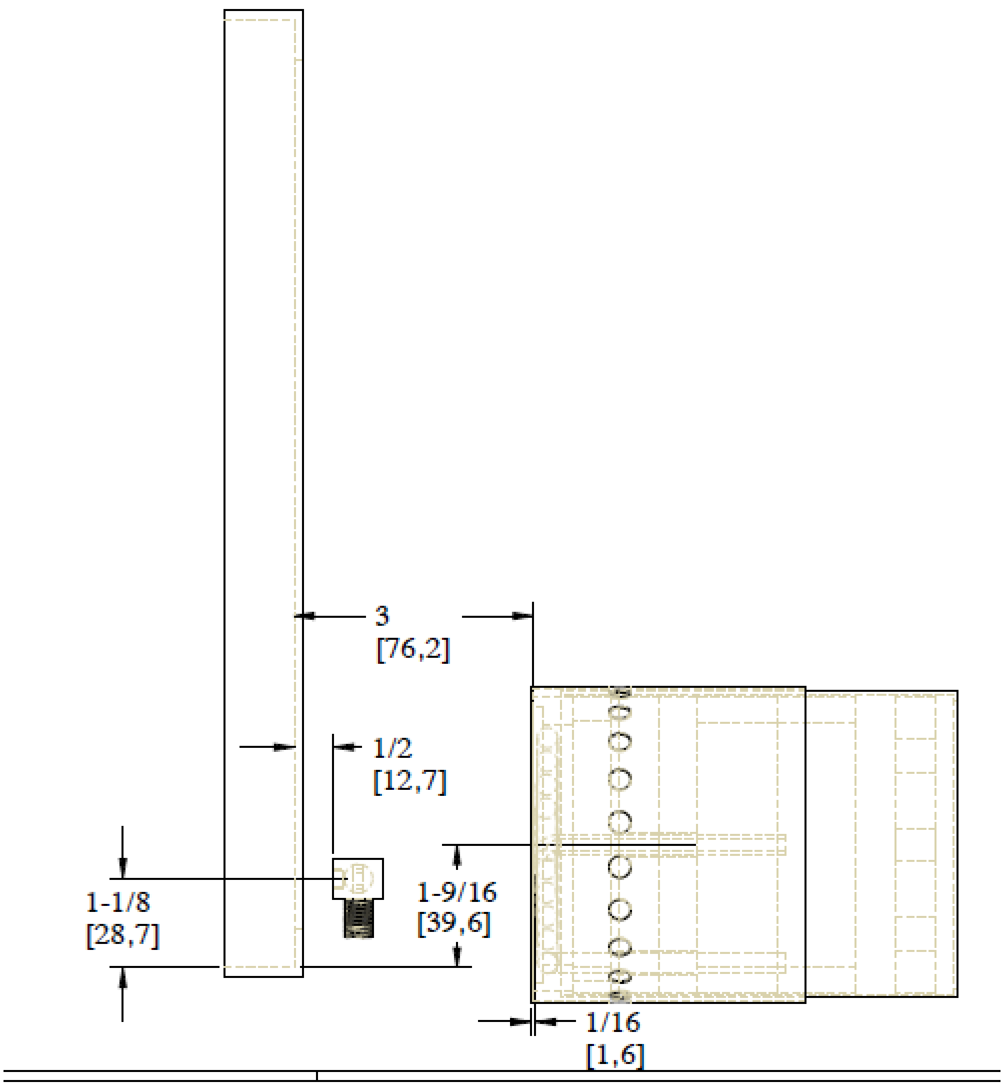


Figure B5-4. Furnace and pilot flame dimensions relative to the sample face

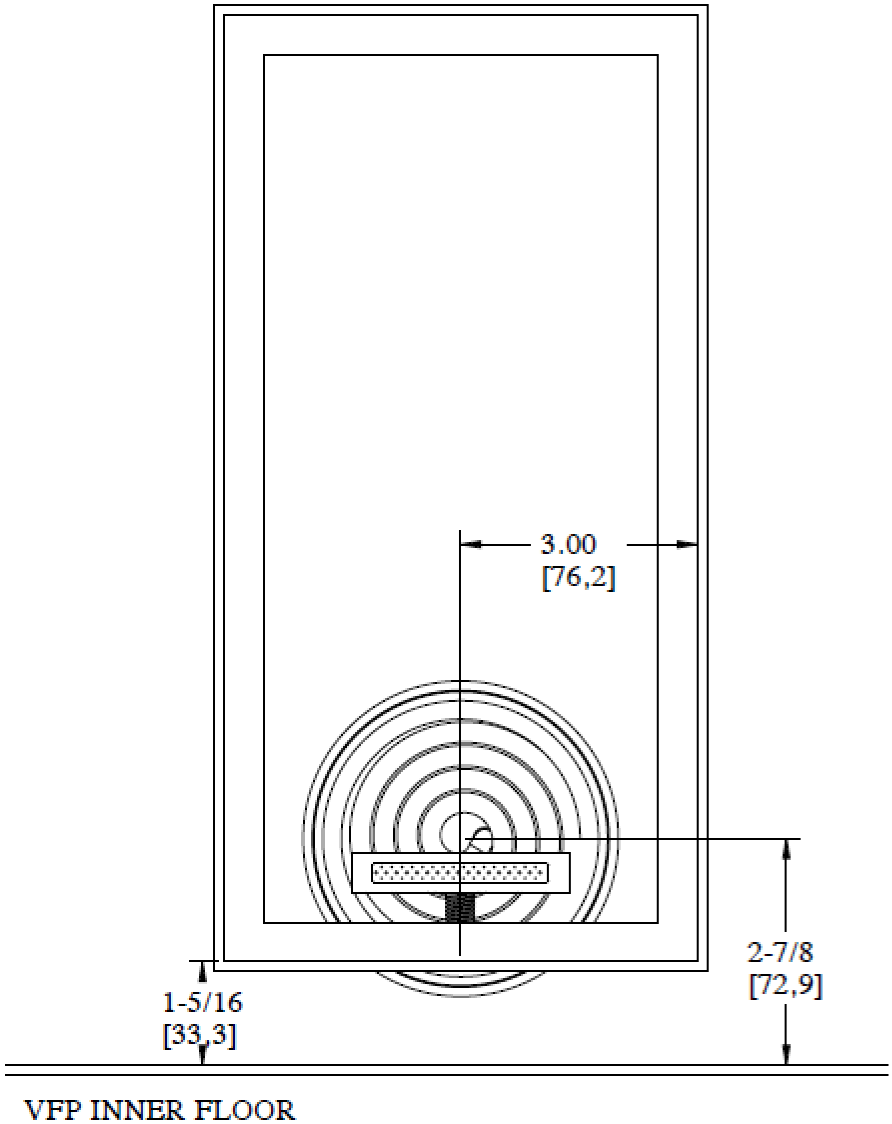


Figure B5-5. Lateral positioning of the pilot burner relative to the centerlines of the heater coil and sample face

B5.6 Apparatus Pre-Heat Procedure

B5.6.1 Switch on AC voltage.

B5.6.2 Begin data collection.

B5.6.3 Adjust AC voltage to achieve 706 watts over a 5-minute average.

B5.6.4 Ensure exhaust fan that will be used during testing is switched on.

B5.6.5 Allow chamber to stabilize for 45 minutes or until the internal chamber temperature stabilizes to 71°C.

B5.6.6 Once the chamber has stabilized, place the vane anemometer at the prescribed locations of the VFP exhaust hood. This is shown as the two marked "x" in figure B5-6.

B5.6.7 Record the average flow velocity through the anemometer.

B5.6.8 Typical flow rates achieved are approximately 135 ± 10 ft/min with a stable chamber and exhaust fan off. The flow rates achieved are approximately 145 ± 10 ft/min with the exhaust fan on.

B5.6.9 Remove the anemometer.

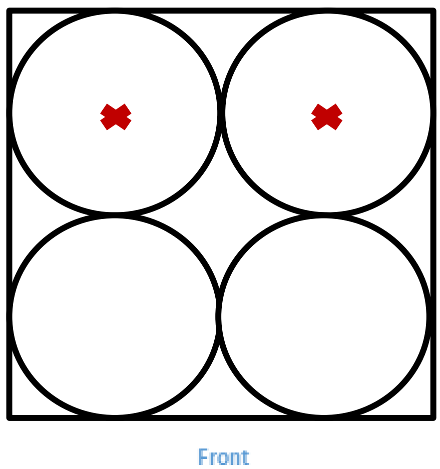


Figure B5-6. Locations of the velocity measurement of the VFP exhaust hood

B5.7 Test Procedure

B5.7.1 Open outer chamber door.

B5.7.2 Open sample door.

B5.7.3 Initiate flow of premixed propane or methane to air mixture to pilot burner.

B5.7.4 Ignite ribbon burner.

B5.7.5 Place test sample in sample holder with the wires toward the radiant heater.

B5.7.6 Secure sample holder with outer retainer ring or spring clamps.

B5.7.7 Push ribbon burner into position.

B5.7.8 Reset stopwatch to 0 and prepare to start timing upon sample door closing.

B5.7.9 Close sample door, begin stopwatch count.

B5.7.10 Pull the ribbon burner back into the standby position at the appropriate flame impingement time for the test being performed. (August 2018 = 30 second impingement time). Do not stop the timer yet.

B5.7.11 Monitor sample flame propagation via viewing windows or video monitor.

B5.7.12 Stop timer when all flaming on sample surface ceases.

B5.7.13 Record after flame time as the time at extinguishment minus the flame impingement time.

B5.7.15 Open door, remove sample, and place under fume hood until off-gassing ceases.

B5.7.15.1 If continuing to test, place next sample in sample holder and repeat.

B5.7.15.2 If testing is complete, place heat-resistant board back into the sample holder, replace outer retainer ring and clamp into place, and close sample door.

B5.8 Burn-Area Measurement Procedure

B5.8.1 Wait until sample has cooled to the touch and is no longer off-gassing.

B5.8.2 Use mild detergent cleaner and a cloth to wipe away sooted areas of the sample face.

B5.8.3 Burn-length measurement. See figure B3-1 for more detail.

B5.8.3.1 For the purposes of this test method, burn areas are considered to be those in which the outer layers of the material have been burned away, breached, or opened, revealing bare wire, indicating that volatiles have escaped the material at that location and could have ignited.

B5.8.3.2 Sooted or discolored areas are not considered part of the burned area.

B5.8.3.3 Of the three wires being tested, the longest burn length will be the recorded length.

B5.8.3.4 The burn length is the vertical dimension.

B5.9 Report

B5.9.1 Report a complete description of the material(s) being tested, including manufacturer, composition, and trade name.

B5.9.2 For each of the three samples tested, report the after-flame time and burn length.

B5.9.3 Record any observations regarding the behavior of the test sample during the test, such as popping, smoke, backside flaming, and the time of the event.

B5.9.4 Provide a record of the test apparatus stability thermocouple measurement and measured test apparatus hood flow velocity.

B5.10 Requirements

B5.10.1 None of the three samples tested shall burn for extended periods of time.

B5.10.2 None of the three samples shall have a burn length greater than 3.5 inches (89 mm).

B5.10.3 If one or more of the samples fail to meet the above requirements, it is possible to run additional recovery tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5=80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

Chapter B6
Test Method to Determine the Flammability and Flame-Propagation Characteristics of Magnesium Alloy

B6.1 Scope

B.6.1.1 Applicability

This test method evaluates the ignition resistance and flammability of magnesium alloy when used in the construction of aircraft cabin components by using an electrically powered radiant panel to show the material adequately self-extinguishes if ignited during an inflight fire.

B6.2 Definitions

B6.2.1 Magnesium Alloy

A magnesium alloy is defined as any solid form of magnesium containing a variety of alloying materials (e.g., zinc) or rare-earth elements (e.g. yttrium). Any component or material containing more than 10 percent elemental magnesium by weight shall be considered a magnesium alloy.

B6.2.2 Sample Set

A sample set consists of three or more replicate test samples of a particular magnesium alloy used in the construction of an aircraft cabin component.

B6.2.3 Flame Impingement Time

Ignition time is the length of time the pilot burner flame is applied to the sample. The ignition time for this test is 120 seconds.

B6.2.4 Zero Position

The zero position is the pilot burner application point on the test sample, which is level with the top surface of the sliding platform upper flange. The zero position coordinates are centerline (± 0.25 inch) with the sliding platform opening (front to back) and 4.5 ± 0.5 inches (102 ± 13 mm) from the outside right edge of the platform frame.

B6.2.5 Melting

Melting is defined as the point at which the sample becomes elastic enough that a significant portion of the sample breaks free and falls from the sample holder. Bending, warping, or sagging alone does not constitute melting.

Occasionally, a material may exhibit “flashing” behavior. Flames appear on the test sample some distance away from the zero position (beyond the allowable limit). This is considered ignition.

B6.2.6 Ignition

Ignition is defined as the first observation of sparking of the magnesium alloy sample when subjected to the pilot burner. The point of ignition is typically a very bright, intense, blue-white flame that can be differentiated from the surrounding yellow-orange flames being produced by the pilot burner. Ignition is often the precursor to burning, when the material experiences sustained ignition.

B6.2.7 Burning

Burning (sustained ignition) is defined as an ignition lasting for 10 consecutive seconds (i.e., the start time of an ignition lasting more than 10 seconds shall be considered the beginning of the burning period in the event that ignition stops and then restarts). For example, if ignition starts and goes for 8 seconds, then stops, then reignites 5 seconds later, the official start of ignition is at the beginning of the reignition, and the initial 8 seconds is ignored.

B6.2.8 Weight Loss

The sample weight loss is the amount of weight a sample loses during exposure to the pilot burner and radiant heat. Molten pieces of the test sample must be retrieved from the surface of the ceramic board upon which the sample holder rests following test completion once sufficient cooling has taken place. Molten/resolidified pieces of the test sample must be blown off with compressed air, to eliminate the inclusion of oxidized material or ceramic board during the final weight measurement. Molten/resolidified pieces of magnesium alloy are distinguishable from oxidized material in that the magnesium alloy cannot be crushed with simple hand tools, such as pliers. Oxidized material is easily crushable. The percentage weight loss for a sample is defined as the pre-test weight of the sample less the post-test weight of the sample and any droppings, expressed as the percentage of the pre-test weight.

B6.2.9 Radiant Heat Source

The radiant heat source is an electric panel having six 3-inch-wide (76.2 mm) emitter strips (see section B6.3.2 Electric Radiant Heat Source).

B6.2.10 Test Series

A series of tests conducted between chamber calibration and system recheck (see sections B6.5.2 Zero Position Calibration and B2.6.3 System Recheck Procedure).

B6.2.11 NIST

The National Institute of Standards and Technology (USA).

B6.2.12 NIST Traceability

A calibration entity using NIST traceable calibration instrumentation.

B6.2.13 Heat Flux

The intensity of the thermal environment to which the sample is exposed when burned. In this test method, the total heat flux is 1.5 BTU/ft^2sec (1.7 W/cm^2).

B6.3 Test Apparatus

B6.3.1 Test Chamber

Tests must be conducted in a radiant panel test chamber as shown in figure B6-1. The test chamber is 55 ± 1 inch (1397 ± 25.4 mm) wide, 20 ± 1 inch (508 ± 25.4 mm) deep (front to back), and 29 ± 1 inch (737 ± 25.4 mm) high from the top of the sliding platform to the top of the chamber frame. All dimensions are taken from the inside of the insulated walls.

The sides, back, and top of the chamber must be insulated with 0.5-inch-thick (12.7 mm), high-temperature insulation material. On the front side, a draft-free, high-temperature glass viewing window must be installed. The window is 9 ± 3 inches (229 ± 76 mm) high by 48 ± 4 inches (1219 ± 102 mm) long. The sliding platform drawer sits below the viewing window. Refer to appendix M for more details on the test chamber.

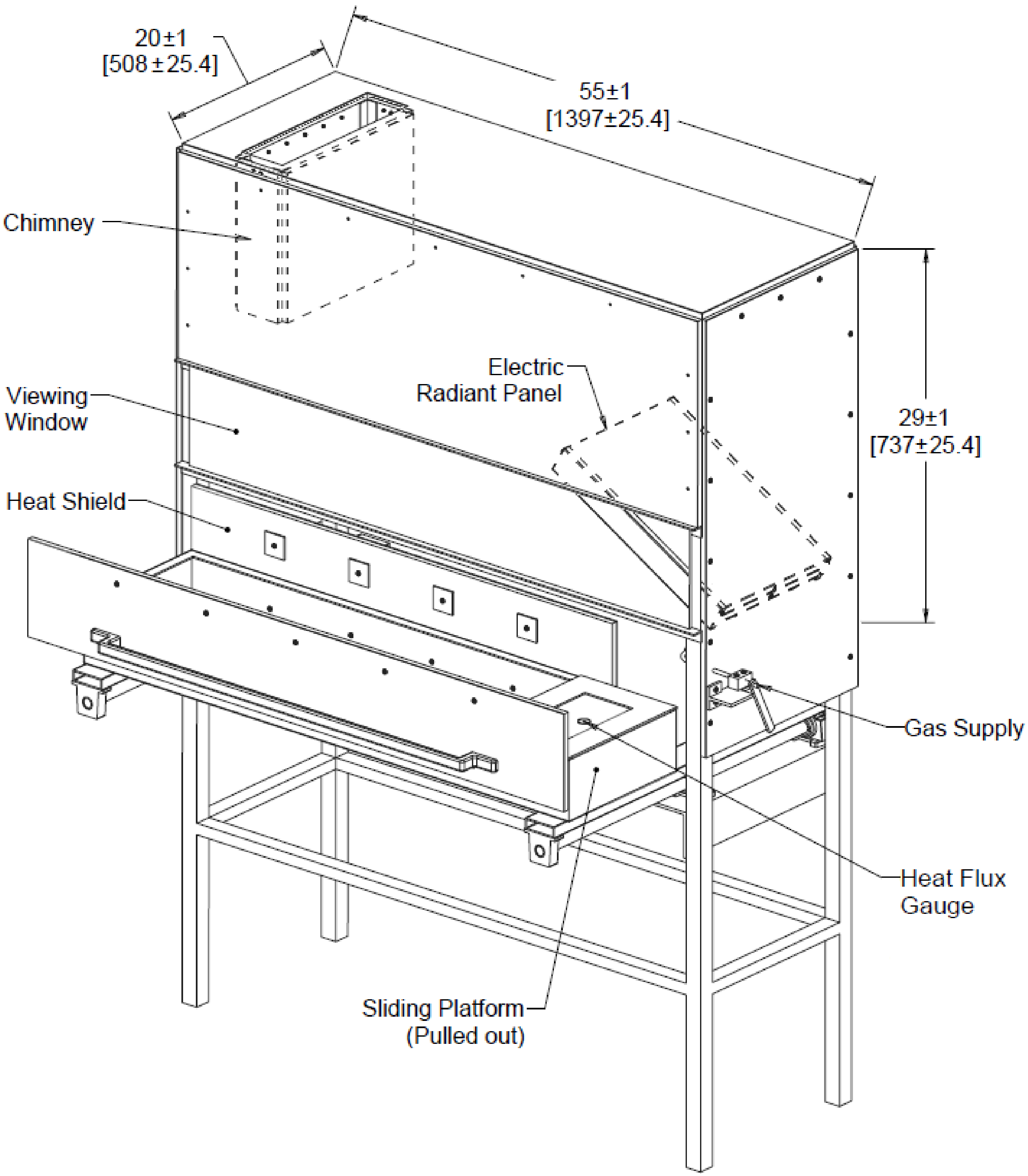


Figure B6-1. Test chamber

The chamber must have an internal chimney that extends to and terminates at the top of the chamber. The chimney is located at the opposite end of the chamber from the radiant heat source (see figure B6-2). Test results can be significantly influenced by the condition of the chimney in the test chamber, which must always be open and clear of obstruction. Refer to appendix M for more details. The test chamber should be located under an exhaust hood to facilitate clearing exhaust smoke during each test.

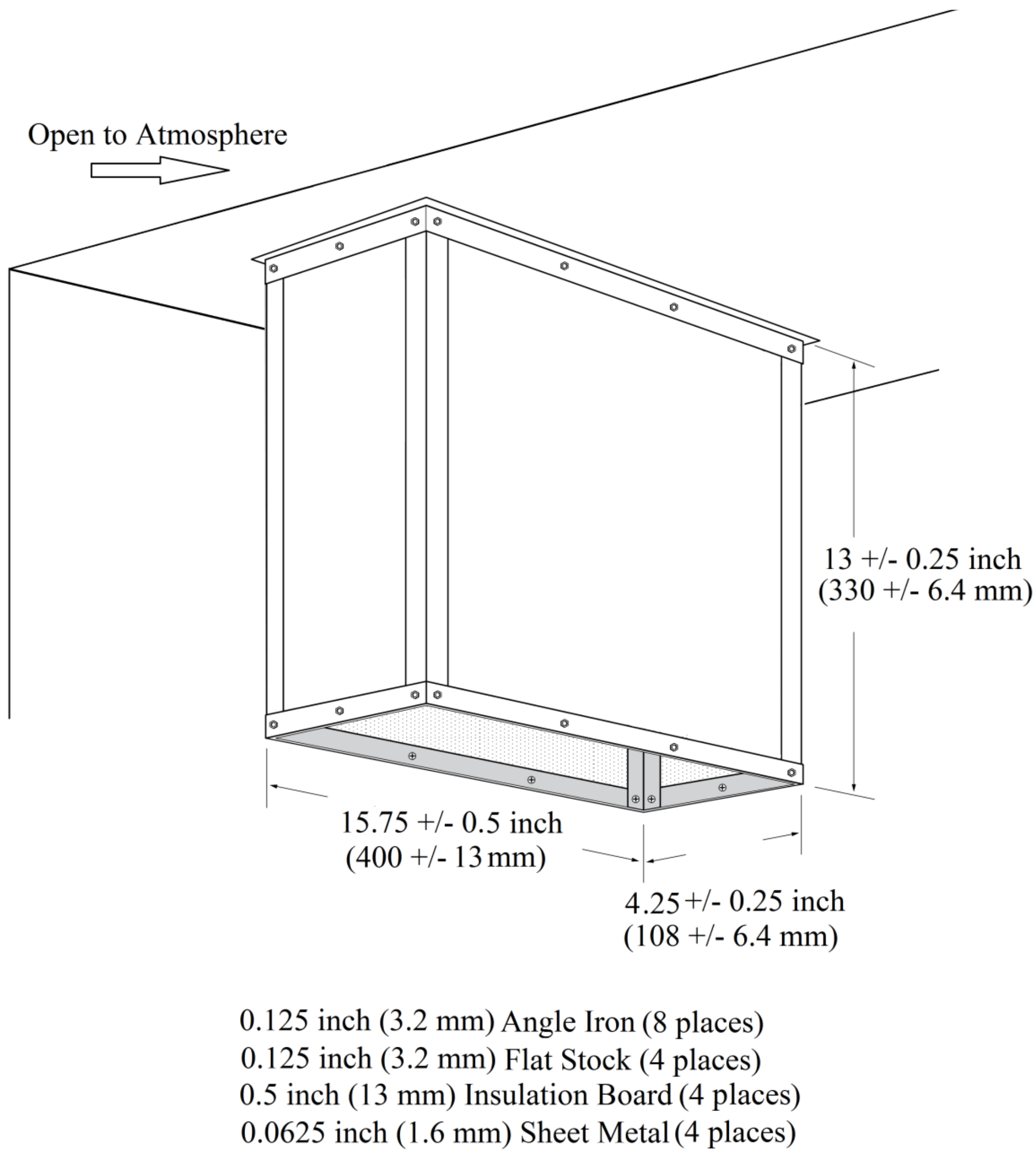


Figure B6-2. Interior view of internal chimney

B6.3.1.1 Air Draft Check

A draft check must be completed periodically if the test chamber is physically moved or if the exhaust system has been changed. Ensure that the chamber is draft free prior to turning on the power to the radiant heat source. To verify this, measure the airflow above the internal chimney with an anemometer device to ensure there is no airflow. Alternatively, an incense cone or other smoke-producing item can be placed on the sliding platform at the zero position with the platform drawer closed.

NOTE: The sliding platform must have insulation boards covering the entire length of the platform for either method of draft checking.

Observe the smoke behavior. If the smoke rises vertically without any drift, it can be regarded as draft free. If testing is performed with an exhaust hood running, the airflow check must be performed with the exhaust hood on.

B6.3.2 Electric Radiant Heat Source

The electric panel must have six 3-inch-wide (76.2-mm) emitter strips, as shown in figure B6-3. The emitter strips must be perpendicular to the length of the panel. The panel must have a radiation surface of 12.6 by 18.75 inches (321 by 476 mm) and be capable of operating continuously at the typical temperature range required to maintain the specified heat flux. The panel surface should be kept clean using a soft bristle brush or soft cloth. A plastic scraper can be used if any debris sticks to the surface. Never use anything metal, such as a wire brush, to clean the panel surface. Refer to appendix M for more details on the electric radiant heat source.

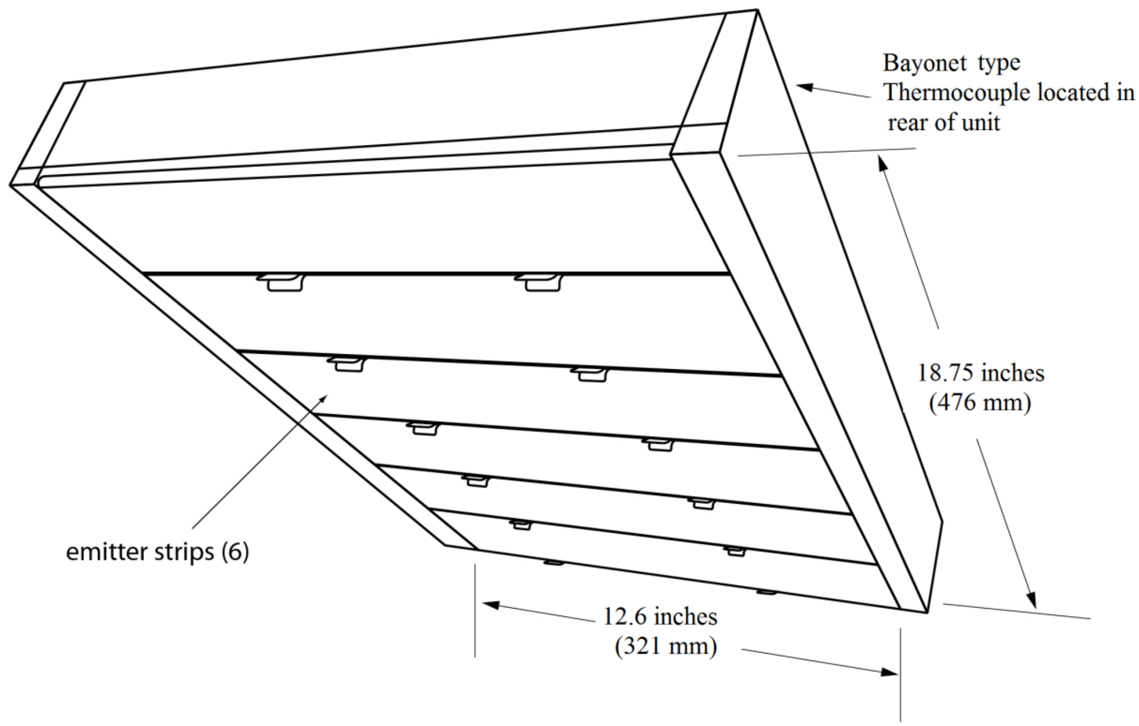


Figure B6-3. Electric radiant panel

B6.3.2.1 Electric Radiant Panel Placement

The electric panel must be mounted in the test chamber at 30 ± 1° to the horizontal sample plane and 7.5 ± 0.125 inches (191 ± 3 mm) above the zero position. Refer to appendix M for proper positioning of the electric radiant panel.

B6.3.3 Sample Holding System

The drawer (also called the sliding platform) serves as the housing for test-sample placement in a fixed and level position (see figure B6-4). The drawer must be at least 2 inches (51 mm) deep and may be up to 6 inches (152 mm) deep. It may be necessary to use shims and multiple sheets of insulation board to obtain the correct height for a magnesium alloy sample to be level with the bottom surface of the sliding platform upper flange. The entire opening on the inside of the drawer must be covered during testing to prevent convective airflow. Refer to appendix M for more details on the sample holding system.

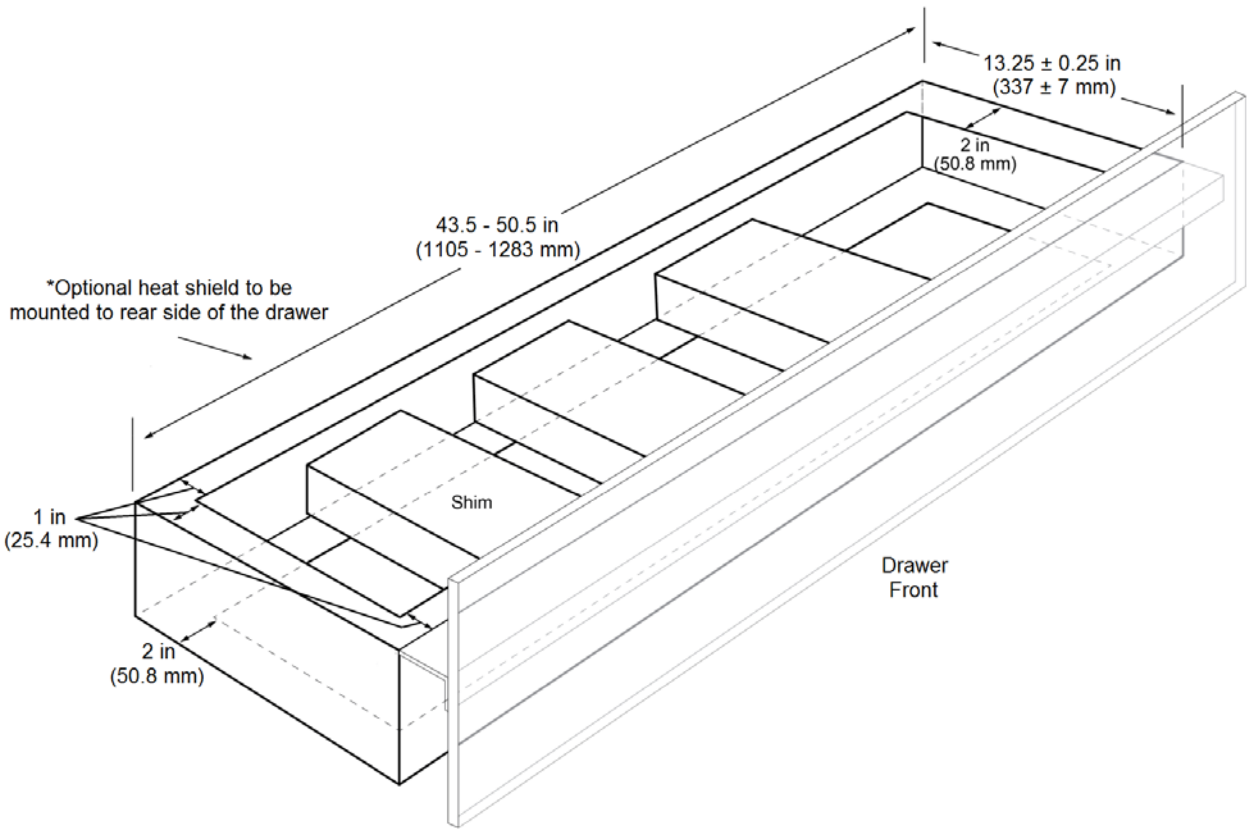


Figure B6-4. Sliding platform

B6.3.3.1 Sample Holder

A sample holding frame is required and must secure the sample in place during testing (see figure B6-5). The thin magnesium alloy sample slides into the slotted sample holder to suspend the sample above the bottom surface plane of the holder. The bottom surface of the holder frame (horizontal) sits on top of several layers of insulation board. It may be necessary to adjust the sample up or down to maintain the 7.5 ± 0.125-inch (191 ± 3-mm) distance from the sample surface to the radiant panel at the zero position.

Some samples tend to warp during testing, which can alter the height of the exposed sample with respect to the pilot flame and radiant heating panel. Test-sample warpage must be monitored throughout the test; excessive sample warpage such that the sample surface moves away from the heating surfaces should be considered a non-test.

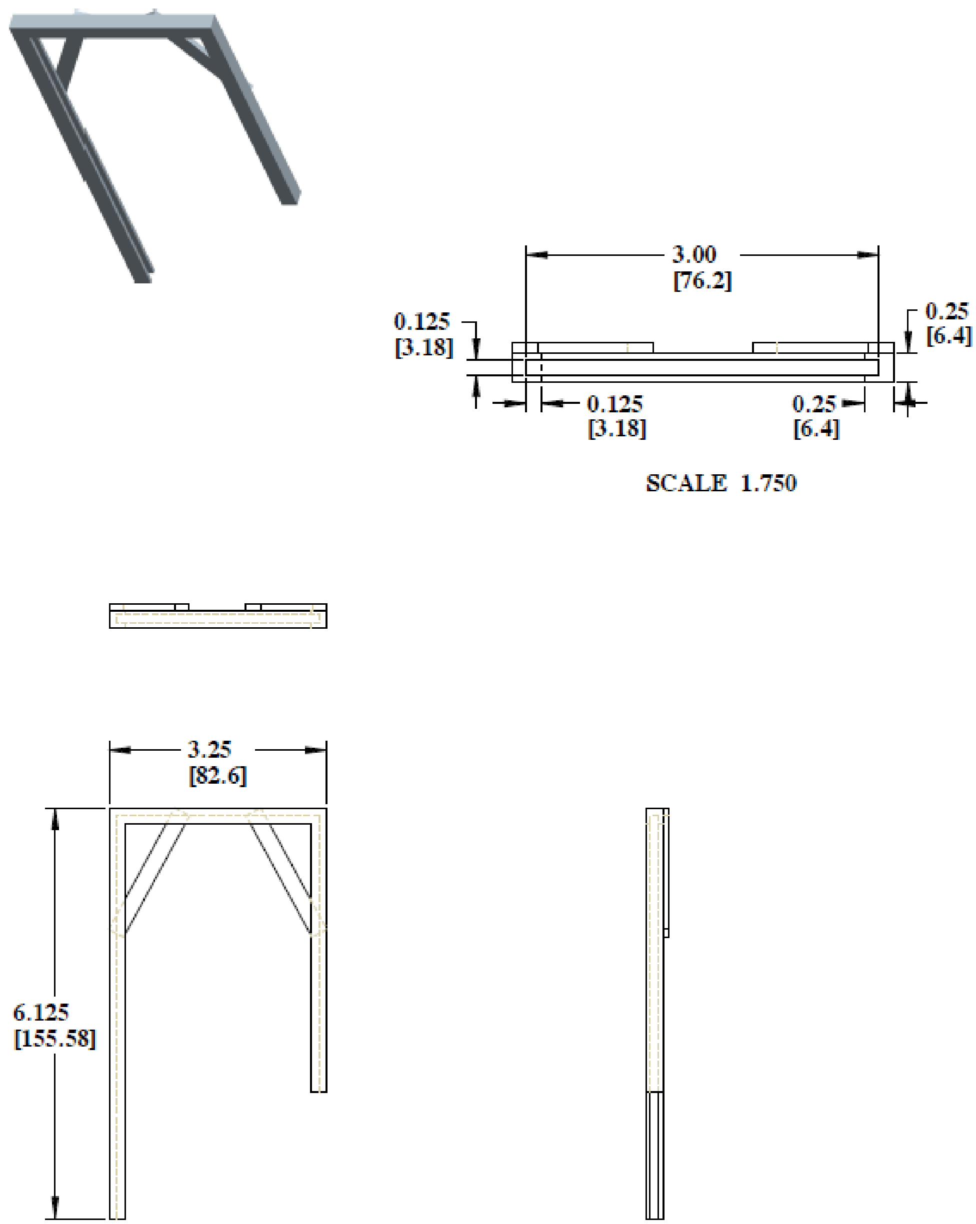


Figure B6-5. Standard sample holder frame

B6.3.3.2 Sample Holder Alignment Tool

An alignment tool must be fabricated of a thin, rigid material for properly locating the sample holder and sample on top of the insulation boards. The alignment tool must center the sample holder with respect to the radiant panel as shown in figure B6-6. Once the sample holder is located in the correct position, it is removed prior to testing.

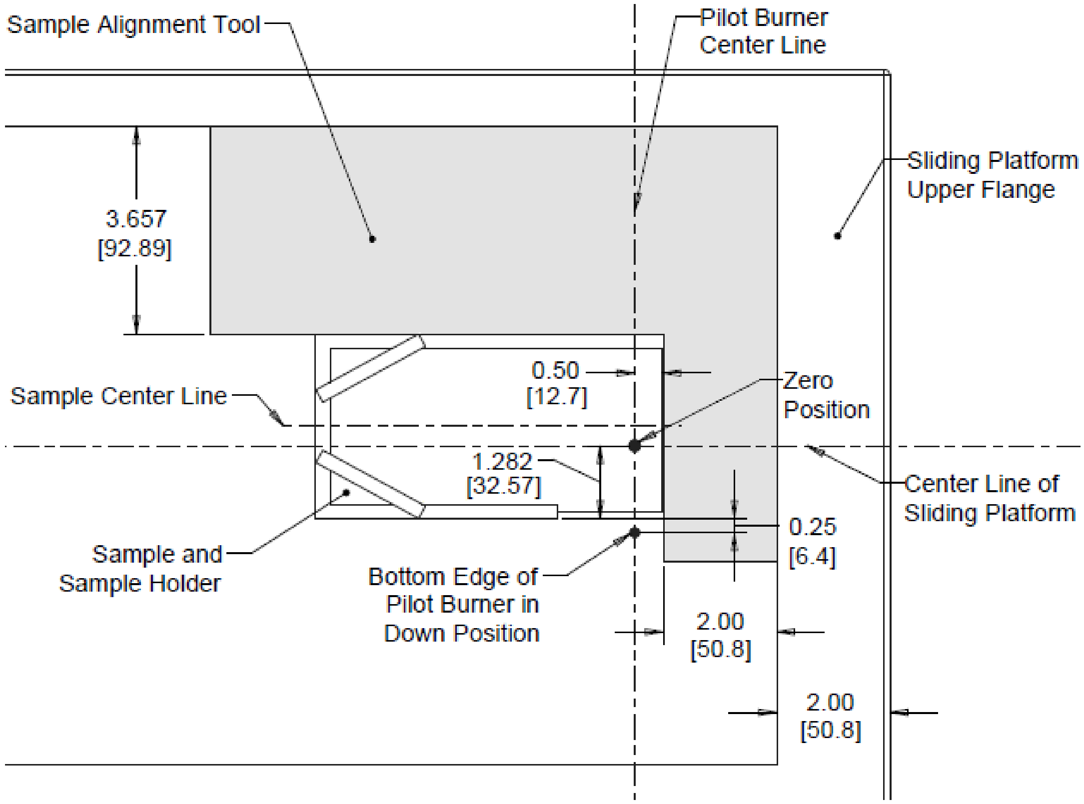


Figure B6-6. Sample holder alignment tool located on sliding drawer

NOTE: Figure B6-6 is an example of an alignment tool for an individual radiant panel apparatus. Small adjustments to the dimensions may be necessary to align the sample correctly with the pilot burner in each individual apparatus.

B6.3.4 Pilot Burner

The pilot burner used to ignite the sample must be a commercial propane Venturi torch with an axially symmetric burner tip and a propane supply tube having an orifice diameter of 0.006 inch (0.15 mm) (see figure B6-7). The length of the burner tube must be 2.875 inches (73 mm). The propane flow must be adjusted via gas pressure through an inline regulator to produce a blue inner-cone length of 0.75 inch (19 mm). A removable 0.75-inch (19 mm) guide, such as a thin strip of metal, may be connected to the top of the burner to aid in setting the flame length. The overall flame length must be approximately 5 inches long (127 mm). An optional high-temperature glass viewing window located on the left wall of the chamber is permitted to ensure proper flame length if it is no larger than 6 inches by 6 inches (152 by 152 mm).

Provisions must be made to move the burner from the test position so the flame is horizontal and at least 2 inches (50.8 mm) above the sample plane (standby position). Do not allow the flame to impinge on the radiant panel. Refer to appendix M for more details on the pilot burner.

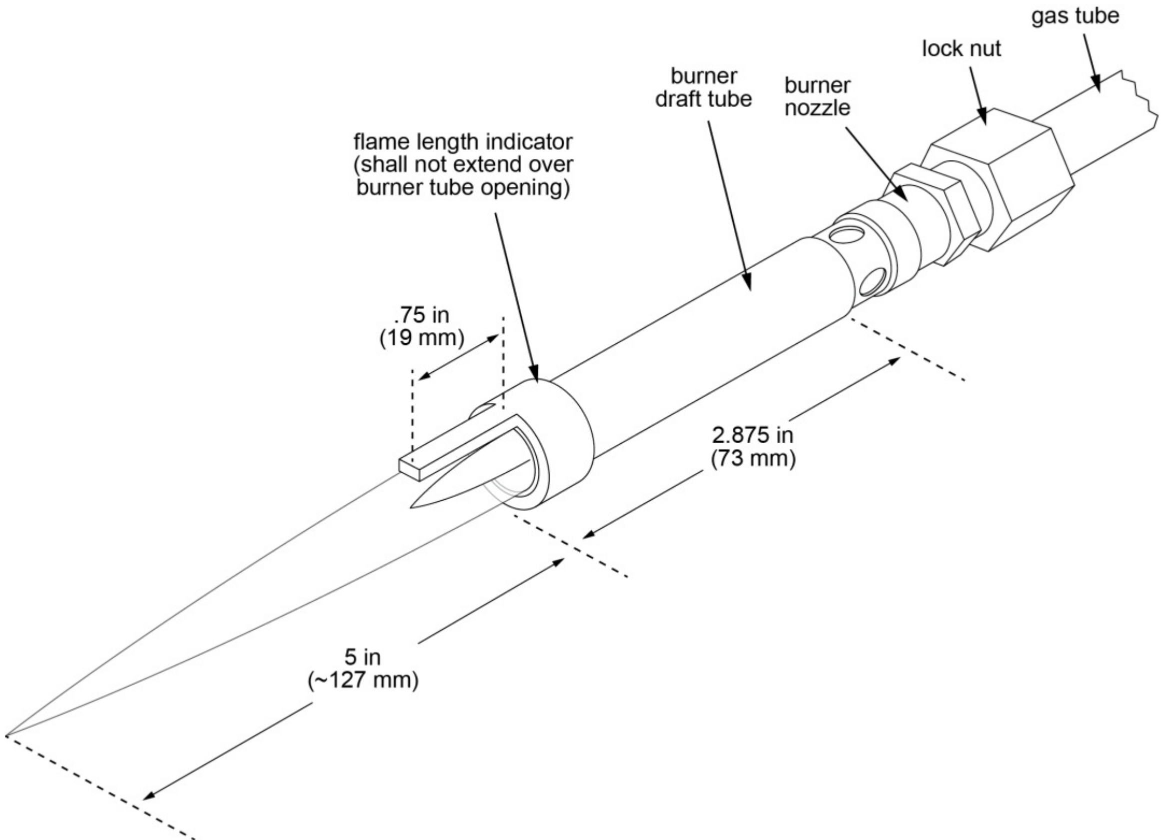


Figure B6-7. Propane Venturi torch (pilot burner)

B6.3.5 Chamber Temperature Thermocouple

A chamber temperature thermocouple is recommended as a third point of reference for overall system health monitoring. It is used in conjunction with the heat-flux measurement and power-controller setpoint. The thermocouple must be a 0.0625-inch (1.59 mm) diameter, stainless-steel, jacketed Type K (Chromel-Alumel) thermocouple, located inside the chamber through a small hole drilled through the back wall. See appendix M for more details on the location of the chamber thermocouple.

Once heat flux is determined and the system is calibrated and ready for testing, the nominal operating range is typically 450 ± 100°F (232 ± 55°C). This temperature should remain consistent (± 5%) in day-to-day testing for an individual machine, but may vary much more across different machines.

B6.3.6 Calibration Assembly

B6.3.6.1 Heat-Flux Gauge

A water-cooled, Gardon-type heat-flux gauge (HFG) must be used to determine the total heat-flux at three positions within the chamber. The HFG cooling water temperature, pressure, and flow shall be maintained within the manufacturer's recommendations. Ensure no condensation occurs on the gauge surface at any time (often caused by cooling water being too cold).

The HFG must have a thin, full-faced, opaque coating of high-temperature, high-emissivity, ultra-flat black paint. The sensitivity of the gauge is a function of the surface condition. Changes in the coating may cause drift in the overall characteristics of the gauge. Regularly inspect the measuring surface for physical damage or dust particles that may have accumulated. Cleaning can be accomplished by gently wiping a soft, water-dampened sponge across the sensor face. Damage done to the coating during the cleaning process will affect the measurement accuracy of the sensor. To maintain accuracy, the measuring surface must be recoated at regular intervals, followed by annual recalibration. See appendix H for full details on the HFG and its required calibration.

B6.3.6.2 HFG Calibration Fixture

The center of an HFG must be mounted in the zero position, as defined in B6.5.2, to determine total heat flux on test samples. The HFG must be mounted in a supporting device protruding through 0.5-inch-thick (12.7 mm) rigid refractory board. Alignment features may be added to help secure the fixture in the correct position. The holder must be constructed so it can be easily moved from one position to the next when conducting a three-position check, or it must be able to measure all three positions at the same time (see section B6.5.4 3 Position Check). Refer to appendix M for more details.

B6.3.7 Instrumentation and Equipment

B6.3.7.1 Data Acquisition

A computerized data-acquisition system must be used to record the output of the HFG and the chamber thermocouple. The data-acquisition system must be capable of recording the HFG output every second during calibration and calculating a 5-minute average of the data. An acceptable data-acquisition system is a 22-bit, analogue-to-digital converter with an accuracy of 0.02 percent of the reading. The data-acquisition system must be calibrated annually to NIST traceability.

B6.3.7.2 Timing Device

A stopwatch or other device, accurate to ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of flame application and time when sample begins to burn (sustained ignition). It is acceptable to use an automatic timer for moving the pilot burner in and out of test position. The timing device must be calibrated annually to NIST traceability.

B6.3.7.3 Digital Weight Scale

A suitable weight scale must be used to determine the initial and final weights of the test sample, and weight of any molten/resolidified portions of the test sample captured in the catch pan. The scale must have a resolution of 0.02 lbs (0.01 kgs) and an accuracy of ± 0.02 lbs (± 0.01kgs).

B6.3.7.4 Test Chamber Enclosure

A suitable test chamber enclosure must be used to reduce or eliminate the possibility of test fluctuation due to air movement. The test enclosure must have a minimum floor area of 10 feet by 10 feet (305 by 305 cm).

B6.3.7.5 Enclosure Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

B6.4 Test Samples

B6.4.1 Sample Configuration

Test samples representing the in-service components must be constructed of the identical magnesium-alloy material to be used in service.

B6.4.2 Sample Number

A minimum of three samples for each magnesium alloy type used for a design configuration must be prepared for testing. These samples must exclude any surface modifications, such as intumescent paints or coatings, or any anodizing processes.

B6.4.3 Sample Size

The samples to be tested must measure 3.0 ± 0.03 inches (76.2 ± 0.8 mm) wide by 6 ± 0.06 inches (152.4 ± 1.6 mm) in length by 0.025 ± 0.0063 inch (0.64 ± 0.16 mm) thick.

B6.4.4 Sample Finish

A machined surface finish to all faces is required for the test samples (e.g. an average roughness value Ra of less than 1.75 μm).

B6.4.5 Sample Coatings

If a finish coating, anodizing, or other standard aerospace grade surface treatment is used on the magnesium alloy in service, it is sufficient to test the coated materials using the 12-second vertical Bunsen burner test method described in Chapter A1 of this handbook (Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials). Vertical Bunsen burner test samples must be fabricated with the coating applied to the magnesium alloy substrate on which it will be used in service, using the production process. The test must be conducted using a substrate thickness representative of the thinnest cross section of the in-service component. If the coating/substrate passes in this thickness (critical test configuration), the coating can be applied to any thicker in-service components of the identical magnesium alloy material without additional testing. Any in-service components having thinner cross sections will require additional vertical Bunsen burner substantiation using that coating/substrate thickness.

B6.4.6 Sample Conditioning

Condition test samples at 70 ± 5º F (21 ± 2º C) and 55 ± 10% relative humidity for a minimum of 24 hours prior to testing. It is permissible to remove more than one sample at a time from the conditioning chamber if the samples are placed in a closed container (a plastic bag is acceptable). The samples must be protected from contamination until tested.

B6.4.7 Sample Placement

The sample holder must be correctly located (longitudinally) on the sliding platform for proper alignment of the pilot burner onto the test sample (see figure B6-8). As shown, the sample holder must be situated such that the edge of the sample is 0.50 inch to the right of the pilot burner zero position. A sample alignment tool must be fabricated from a rigid material to allow quick and accurate placement of the sample holder onto the sliding drawer. The most practical approach is to fabricate the tool to fit into the upper flange of the sliding drawer, up against the right rear inside corner.

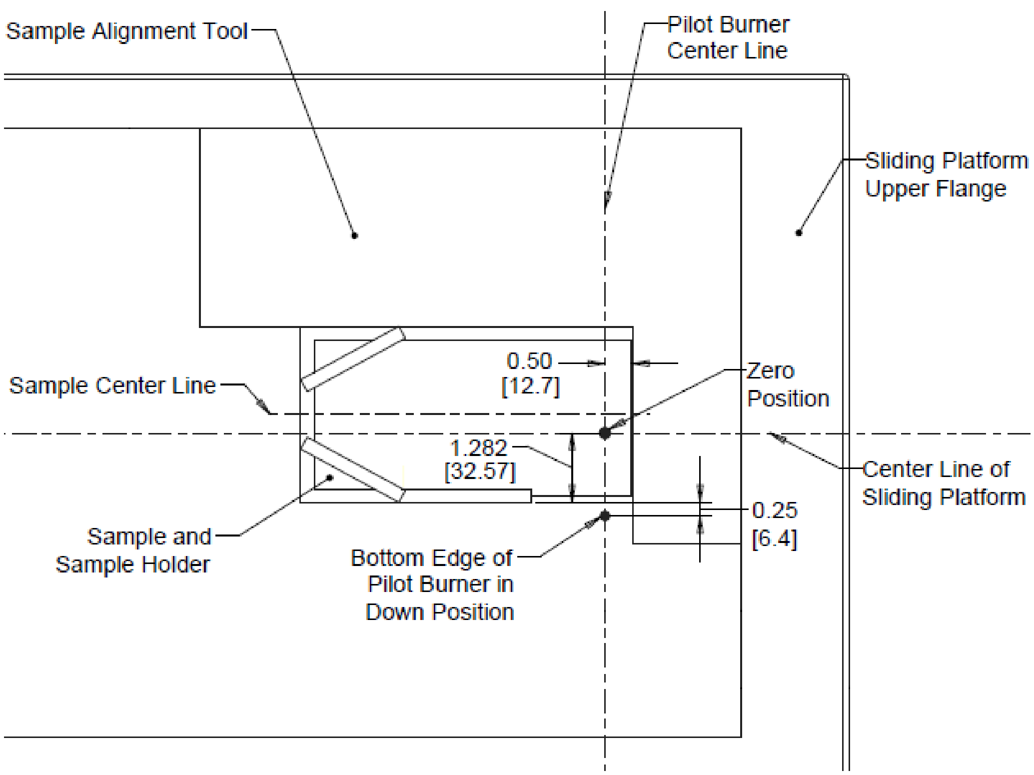


Figure B6-8. Sample holder alignment tool located on sliding drawer

The sample holder must be placed so that the top surface of the sample is level with the top surface of the sliding platform upper flange (see figure B6-9). When placing the sample holder on top of the insulation boards, some adaptation is necessary to precisely position the test sample. It is permissible to use thin shims of sheet metal to bring the top surface up to the correct height; however, the shims must be positioned under the uppermost insulation board to prevent heat transfer to any metallic shims. It is critical that the top of the sample be at the proper height for the correct exposure of the test sample to the radiant heat source (see section B6.2.4 Zero Position).

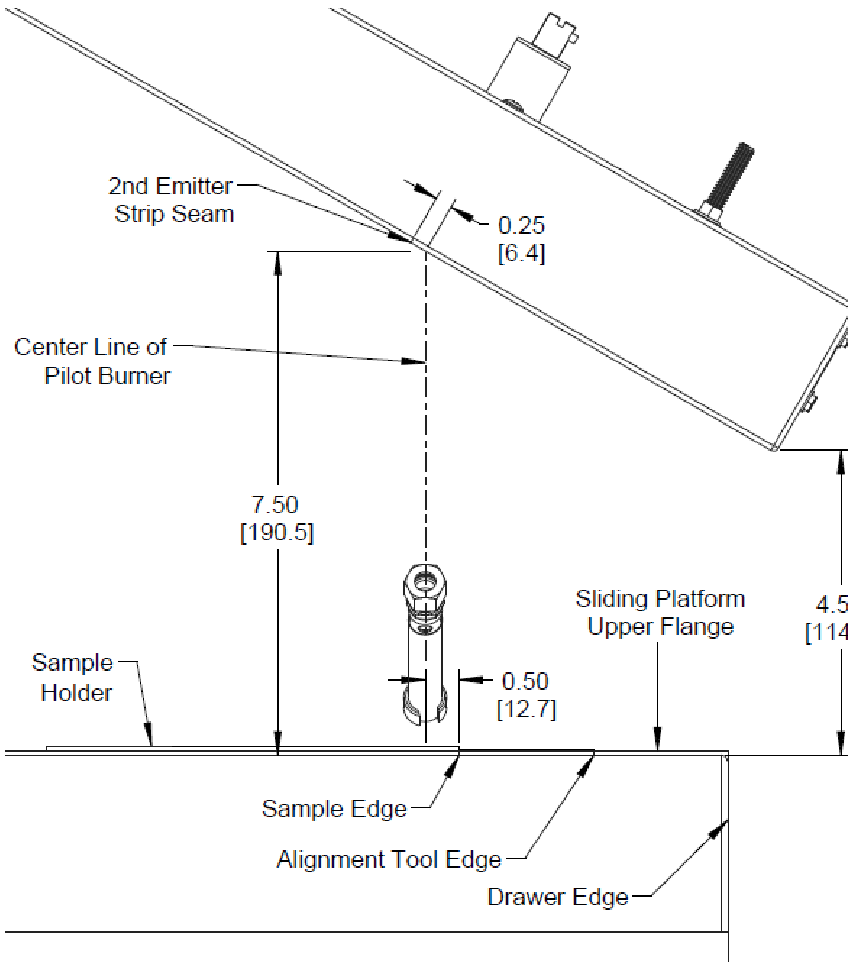


Figure B6-9. Sample holder positioning on sliding drawer

The sample holder alignment tool must also correctly position the sample holder (laterally) so that the sample is centered with respect to the radiant panel above (see figure B6-10). When the sample holder is centered, the lower tip of the end of the pilot burner will be situated 0.25 inch from the edge of the sample holder (pilot burner in the down position).

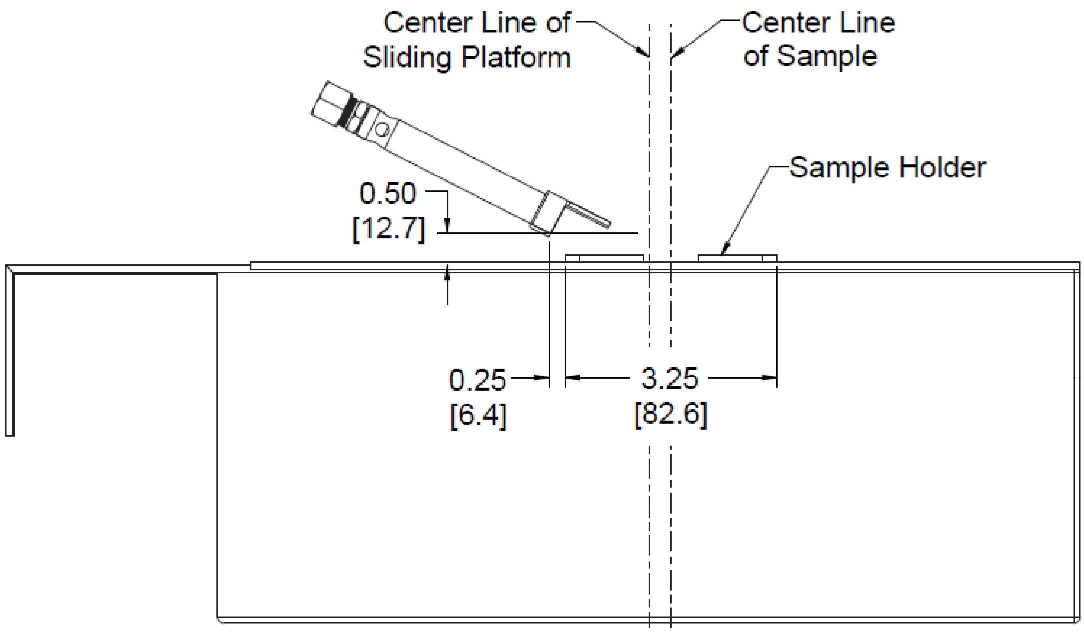


Figure B6-10. End view of sample position on sliding platform

NOTE: Proper alignment-tool fabrication and measurement are necessary for each lab because slight variations may exist from one apparatus to another.

B6.5 Preparation of Apparatus

B6.5.1 General Information

Prior to daily testing, a zero-position calibration (section B6.5.2) and system upset check (section B6.5.3) must be conducted. A recheck must be conducted immediately following the completion of a test series to ensure data are valid. If the recheck heat-flux value is not within range, the test data are considered to be invalid (section B6.6.4). Once a recheck is conducted, material testing must be continued within 30 minutes, or the equipment must be allowed to cool to ambient conditions (approximately 1 hr) if testing has been completed. Heat flux must be calculated using a 5-minute rolling average.

Calibration of the test apparatus must be completed no sooner than 25 minutes and no later than 90 minutes after turning the radiant panel on. If calibration is not able to be completed within 90 minutes, it could indicate a problem with the machine; the equipment must be allowed to cool to ambient conditions (approximately 1 hr) before repeating the “zero position calibration” and “system upset check” procedure.

NOTE: The actual heat flux generated by the radiant panel has a direct influence on test results. Experiments suggest that variations in heat flux from the ranges specified can influence both the melt time and burn time, although not necessarily in the same way. A slightly higher heat flux might be critical for one parameter, whereas a slightly lower heat flux might be critical for the other parameter. It is essential that heat flux be maintained as specified in table B6-1.

Table B6-1. Heat-flux ranges for thermal/acoustical insulation test

	W/cm^2			
Range	Zero Position	#1 Position	#2 Position	Recheck
High	1.72	1.73	1.67	1.75
Nominal	1.70	1.70	1.64	1.70
Low	1.69	1.66	1.57	1.64
	BTU/ft^2*sec			
Range	Zero Position	#1 Position	#2 Position	Recheck
High	1.51	1.52	1.47	1.54
Nominal	1.50	1.50	1.44	1.50
Low	1.49	1.46	1.38	1.44

B6.5.2 Zero-Position Calibration Procedure

B6.5.2.1 Install the HFG calibration fixture at the zero position. Place a sheet of noncombustible material on top of the sliding platform adjacent to the HFG fixture (to the left) to prevent heat loss during calibration. The entire opening of the inside of the drawer must be covered.

B6.5.2.2 Ensure the HFG surface is clean and properly aligned, and that cooling water is flowing. Close the sliding platform.

B6.5.2.3 The pilot burner must be off and in the down position (test position).

B6.5.2.4 Begin heating and allow a minimum time period of 25 minutes for equipment to stabilize. The temperature of the radiant panel must reach its set point.

B6.5.2.5 Calculate the zero-position heat flux using the HFG millivolt signal and its calibration constant, and begin observing a 5-minute rolling average.

B6.5.2.6 Once a stable heat flux is determined, adjust the temperature setting as necessary, and restart the 5-minute rolling average. Repeat this process until the zero-position heat flux is within the appropriate range (table B6-1).

B6.5.3 System Upset Check

Prior to testing, a system upset check must be completed once the zero-position heat flux is determined to be stable and within tolerance. The heat flux must return to the zero-position range, as specified in table B6-1 during this check.

B6.5.3.1 Raise the pilot burner to the standby position.

B6.5.3.2 Pull the sliding platform out to its stop and hold open for 30 seconds (simulated material load time).

B6.5.3.3 After 30 seconds, close the sliding platform completely.

B6.5.3.4 Lower the pilot burner into the test position.

B6.5.3.5 Allow the process-controller temperature to return to its original setpoint (± 1°F).

B6.5.3.6 Begin the 5-minute heat flux rolling average calculation.

B6.5.3.7 After the 5-minute average heat flux is determined to be correct (zero position), proceed to the next step, or make adjustments as necessary and repeat (refer to table B6-1).

B6.5.3.8 Raise the pilot burner to the standby position, then, using caution because it may be very hot, open the drawer and remove the HFG calibration assembly.

NOTE: It is acceptable to leave the assembly at the left end of the chamber during material testing if the HFG is protected and cooling water is flowing to prevent damage to the sensor.

B6.5.4 Three-Position Check

A three-position heat-flux check is required whenever the radiant panel is replaced or whenever the HFG has been recalibrated or replaced. To ensure the panel is operating correctly, there must be a drop in observed heat flux as the distance from the zero position increases (position #2). Allow the HFG to reach steady state at each position before recording the heat flux. The distance between the centerlines of each of the three positions is 2 ± 0.0625 inches (50.8 ± 1.6 mm). As the holder is being moved, make sure to place high-temperature boards to the right of the holder to prevent heat loss. For daily testing, a heat flux check in the zero position is sufficient.

B6.5.4.1 Conduct “Zero Position Calibration” (see section B6.5.2)

B6.5.4.2 Conduct “System Upset Check” (see section B6.5.3)

B6.5.4.3 Raise the pilot burner to the standby position, open the drawer, and move the calibration assembly to position #1. Move insulation boards to the left. Cover any gap that opened to the right side of the calibration assembly.

B6.5.4.4 Close the drawer and lower the pilot burner into test position. Calculate the 5-minute heat-flux rolling average to confirm heat flux is within range for position #1 (refer to table B6-1).

B6.5.4.5 Raise the pilot burner to the standby position, open the drawer, and move the calibration assembly to position #2 (refer to table B6-1). Move insulation boards to the left. Cover any gap that opened to the right side of the calibration assembly.

B6.5.4.6 Close the drawer and lower the pilot burner into test position. Calculate the 5-minute heat-flux rolling average to confirm heat flux is within range for position #2.

B6.6 Test Procedure

B6.6.1 General Information

Once calibration is verified, testing can begin. If testing is not conducted for a period of time exceeding 30 minutes, the HFG calibration assembly must be installed and allowed to stabilize for a minimum of 5 minutes, followed by a “System Upset Check” (section B6.5.3). The heat flux must return to the zero-position range, as specified in table B6-1, during this check.

NOTE: It is extremely important that each test must be carefully observed to determine the melt, ignition, and burn times accurately.

B6.6.2 Test Sequence

B6.6.2.1 Conduct “Zero Position Calibration” (see section B6.5.2)

B6.6.2.2 Conduct “System Upset Check” (see section B6.5.3)

B6.6.2.3 Stack up insulation boards inside the drawer so the top surface of the test sample will be level with the top surface of the drawer upper flange when the sample holder is sitting on top of the insulation boards. The rest of the inside of the drawer should be completely covered with insulation boards so no convective airflow can pass through.

B6.6.2.4 Ignite the pilot burner and keep it in the standby position. Verify that the flame is the correct length.

B6.6.2.5 Weigh the test sample.

B6.6.2.6 Insert the test sample into the sample holder. Open the drawer, and place the test sample and holder on the sliding platform using the sample holder alignment tool (see figures B6-8, B6-9, and B6-10). Once aligned, remove the alignment tool.

B6.6.2.7 Immediately push the sliding platform into the chamber (within 3 seconds or less).

B6.6.2.8 Within 1 second or less, bring the pilot burner flame into contact with the sample at the zero position, and simultaneously start the timer.

B6.6.2.9 After a flame-impingement time of 120 seconds, quickly lift the burner flame to the standby position within 1 second or less. Allow the test to progress for an additional 120 seconds.

B6.6.2.10 Open the drawer, and continue to observe the test sample remaining in the sample holder. If the sample is still burning, measure the time when the burning ends, then remove the sample holder and test sample. Set sample and any remnants aside to cool. To avoid excessive heat loss, keep the drawer closed when not loading, measuring, or unloading samples.

B6.6.2.11 Weigh the sample and remnants after carefully blowing off any oxidation or residue.

NOTE: This process should be completed within 1 hour of the end of the test.

B6.6.2.12 When test series is complete, conduct system "Recheck" to verify posttest heat flux is within range. If not within range, previous test data are invalid (refer to table B6-1).

B6.6.3 System Recheck Procedure

B6.6.3.1 Install the HFG fixture at the zero position. Place a sheet of noncombustible material on top of the sliding platform adjacent to the calorimeter fixture (to the left) to prevent heat loss during calibration. All gaps within the drawer opening that could allow air to flow through must be covered.

B6.6.3.2 Ensure the HFG surface is clean, properly aligned, and that cooling water is flowing. Close the sliding platform.

B6.6.3.3 The pilot burner must be off and in the down position (test position).

B6.6.3.4 Allow the system to stabilize for 25 minutes.

B6.6.3.5 After 25 minutes, calculate the zero-position "Recheck" heat flux using the HFG millivolt signal and its calibration constant, and begin a 5-minute rolling average.

B6.6.3.6 After 5 minutes (no adjustments permitted), verify heat flux is within the "Recheck" range (table B6-1).

B6.6.3.7 You may continue material testing after a "Recheck," or shut down the system and allow the apparatus to cool to ambient conditions if testing has been completed.

B6.7 Report

B6.7.1 Setpoint Temperature

Record the temperature set point for the radiant panel power controller.

B6.7.2 Zero-Position Calibration

Record the 5-minute average heat-flux value (BTU/ft^2-sec or W/cm^2).

B6.7.3 Chamber Temperature

Report the pretest chamber temperature after calibration.

B6.7.4 System Recheck

Record the 5-minute average heat-flux value (BTU/ft^2*sec).

B6.7.5 Material Identification

Fully identify and describe the test sample (e.g., alloy, grade, thickness).

B6.7.6 Melting

Report the melting time in seconds for each sample tested.

B6.7.7 Ignition Time

Report the ignition time in seconds for each sample tested.

B6.7.8 Burn Time

Report the time burning began for each sample tested.

B6.7.9 Self-Extinguishment Time

If the sample burns, report the time for each sample to self-extinguish.

B6.7.10 Notes/Comments

Report any occurrences of sparking, melting, glowing, swelling, flashing, or char.

B6.7.11 Weight Loss

Calculate and record the weight percentage loss of each test sample by combining the final weight of the sample remaining in the holder and any additional remnants removed from the top of the insulation. Ensure that the remnant weight includes only metallic components and no oxidized material or insulation board material. The combined weight of the tested sample and remnants can be subtracted from the initial weight of the sample. This value can then be divided by the initial weight and the value multiplied by 100 to determine the percentage weight loss.

B6.8 Requirements

B6.8.1 Ignition Time

The time to ignition, after placement of the pilot burner flame, must not be less than 30 seconds.

B6.8.2 Weight Loss

The calculated weight loss may not exceed 30 percent.

B6.8.3 Self Extinguishment

Measuring the exact time of flame extinguishment of the test sample is difficult and subjective, given the nature of a burning magnesium alloy. The transition of the alloy from burning to self-extinguishment typically happens gradually rather than instantaneously, as is the case with most traditional cellulosic materials. For this reason, a maximum allowable time until self-extinguishment of the test sample is not required, per se. However, if new magnesium alloys become available that exhibit extended burn periods prior to self-extinguishment, but still pass the weight loss criteria, it may be necessary to incorporate a maximum time requirement for the alloy to self-extinguish.

B6.8.4 A minimum of three samples must be tested. If the minimum three samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experience an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

CHAPTER C: FLAMMABILITY TESTS FOR CARGO COMPARTMENTS

Chapter C1
45-Degree Bunsen Burner Test for Cargo Compartment Liners and Waste Stowage Compartment Materials

C1.1 Scope

This test method is intended for use in determining the resistance of materials to flame penetration and to flame and glow propagation when tested according to the 30-second, 45-degree Bunsen burner test specified in 14 CFR 25.

C1.2 Definitions

C1.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the sample. For this test, the ignition time is 30 seconds. Ignition time should start only after the flame has stabilized and is properly positioned under the test sample.

C1.2.2 Flame Time

Flame time is the time in seconds that the sample continues to flame after the burner flame is removed from under the sample.

C1.2.3 Glow Time

Glow time is the length of time in seconds that the sample continues to glow after any flaming combustion ceases following the removal of the ignition flame.

C1.2.4 Flame Penetration

Flame penetration occurs if the Bunsen burner flame penetrates (passes through) the test sample through a hole or crack in the sample that forms during the test ignition time. Flaming combustion on the top of the sample that results from auto ignition is not considered flame penetration in this test.

C1.3 Test Apparatus

C1.3.1 Test Cabinet

Tests will be conducted in a draft-free cabinet or other equivalent enclosure acceptable to the FAA. The test cabinet must have a viewing window set up such that both sides of the sample can be observed during testing. 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 thick (1 mm), will be used for the bottom surface of the chamber. Refer to appendix I for more details on the test cabinet.

C1.3.2 Sample Holder

The sample holder will be fabricated of corrosion-resistant metal and will be capable of securely positioning the sample at a 45-degree angle, with the vertical as shown in figure C1-1. The holder will be able to accommodate samples up to 1-inch (25 mm) thick.

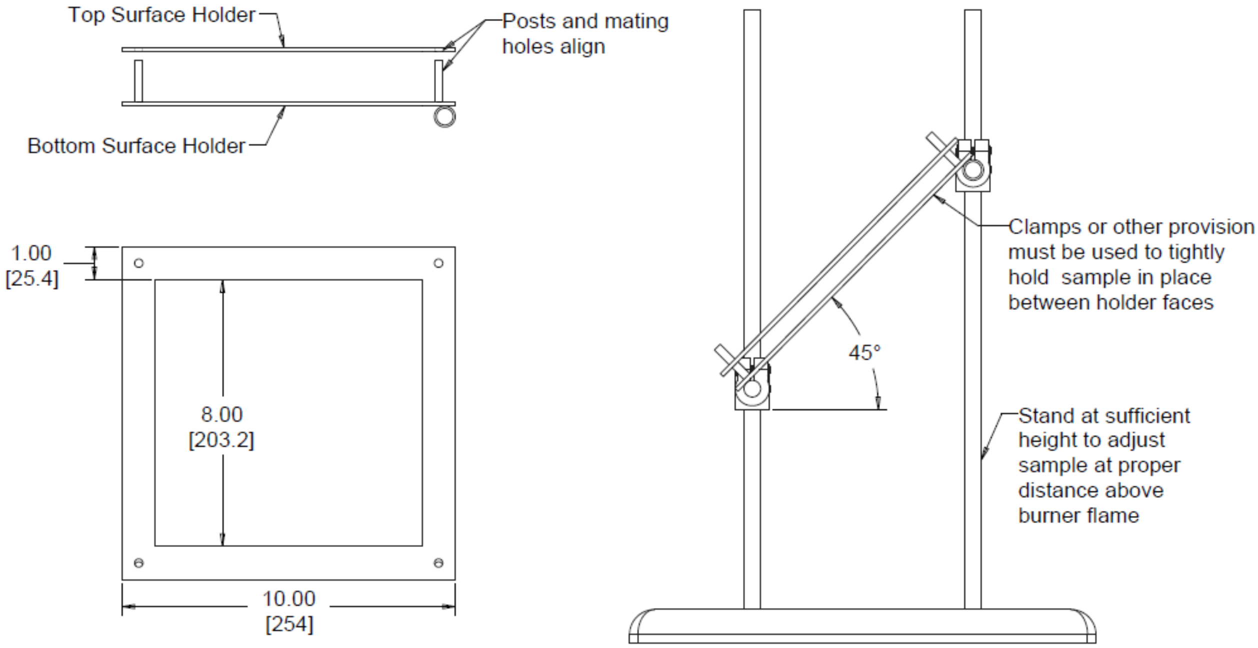


Figure C1-1. 30-second, 45-degree Bunsen burner test-sample frame and stand

C1.3.3 Burner

The burner must be a Bunsen or Tirrill type. The burner must have a 0.375-inch (10 mm) inside diameter barrel. A Tirrill burner is 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. If using a Bunsen burner, there must be a means of regulating the gas flow (e.g., a needle valve) to achieve the flame height, and all aspirating holes at the bottom of the burner must be closed. Either burner should have a 0.036 + 0.0002/-0.0003-inch orifice. Refer to appendix I for more burner details.

C1.3.3.1 Burner Fuel

A diffusion flame using methane gas of 99 percent certified purity (CP) must be used (i.e., without adding air through the aspirating holes at the bottom of the burner barrel).

C1.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure C1-2. A control-valve system with a delivery rate designed to furnish gas to the burner inlet under a pressure of 2.5 ± 0.25 psi (17 ± 2 kPa) at the burner inlet must be installed between the gas supply and the burner. If using a Bunsen burner, a needle valve needs to be placed between the fuel pressure regulator and burner inlet to control the flame height.

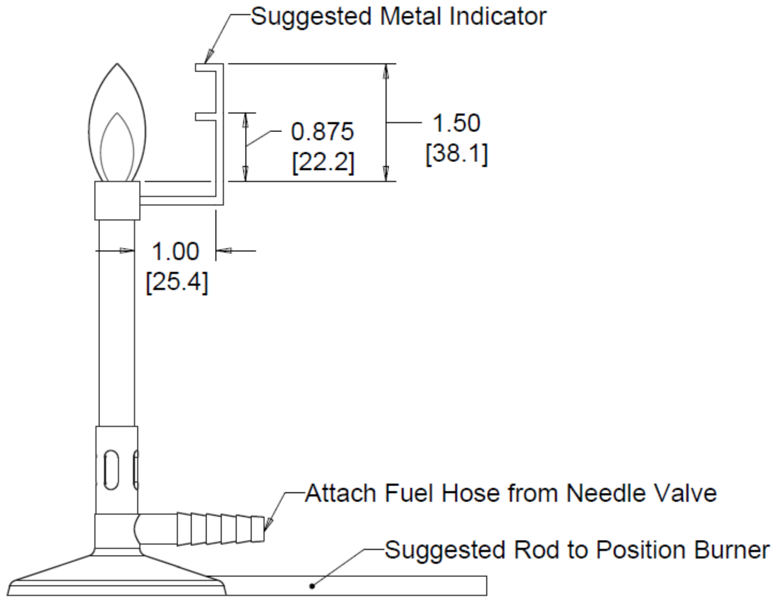


Figure C1-2. Burner plumbing and burner flame-height indicator

C1.3.3.3 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 is spaced 1 inch (25 mm) away from the burner barrel, as shown in figure C1-2. 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 the proper flame profile is achieved when the height of the inner cone is 0.875 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long. 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. However, the inner cone of the flame is more visible and easily seen.

C1.3.3.4 Burner Positioning

There will be means provided to position the burner directly below the center of the sample and also to move it at least 3 inches (76 mm) from the sample.

C1.3.4 Timer

A stopwatch or other device, accurate to within ±1 second per 8 hours (±3 sec per day), must be used to measure the time of application of the burner flame, the flame time, and the glow time.

C1.4 Test Samples

C1.4.1 Sample Selection

Samples 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 sample may be cut from any location in the fabricated part. Fabricated units, such as sandwich panels, will not be separated into individual component layers for testing.

C1.4.2 Sample Number

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

C1.4.3 Sample Size

The sample will be a square large enough to allow an exposed area of 8 inches (203 mm) by 8 inches (203 mm). A nominal sample size of 10 inches (254 mm) by 10 inches (254 mm) has been found satisfactory; however, actual sample size is dependent on the details of the sample holder selected for the test equipment.

C1.4.4 Sample Thickness

The sample thickness will be the same as that of the part to be qualified for use in the aircraft, with the following exceptions:

C1.4.4.1 If the part construction is used in several thicknesses, the minimum thickness will be tested.

C1.4.4.2 Parts that are smaller than the size of a sample and cannot have samples cut from them will be tested using a flat sheet of the material used to fabricate the part in the actual thickness used in the airplane.

NOTE: According to § 25.853, the sample thickness must be no thicker than the minimum thickness to be qualified for use in the airplane. If the test facility has questions concerning the flammability of a thicker sample, then testing may be conducted and test data recorded for further review.

C1.5 Conditioning

Condition samples at 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum. Remove only one sample at a time from the conditioning environment immediately before testing.

NOTE: As stated in § 25.853, only one sample 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 sample at a time only if each sample is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination, such as dirty lab tops and soot in the air, until the sample is subjected to the flame.*

C1.6 Procedure

C1.6.1 Burner Adjustment

C1.6.1.1 Ensure that the air supply to the burner is shut off.

C1.6.1.2 Open the valve in the gas line fully and light the burner.

C1.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height in accordance with section C1.3.3.3.

C1.6.2 Test Procedure

C1.6.2.1 Place the burner at least 3 inches (76 mm) from where the edge of the sample will be located during the test.

C1.6.2.2 Place the sample in the holder with the surface to be exposed when installed in the aircraft toward the flame. The sample will be positioned so that one-third of the height of the flame is in contact with the material when the test is in progress.

C1.6.2.3 Close the cabinet door and keep it closed during the test. It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

C1.6.2.4 The timer must be started immediately on positioning the burner. Position the burner so that the center of the burner barrel is under the center of the bottom surface of the sample, as shown in figure C1-3.

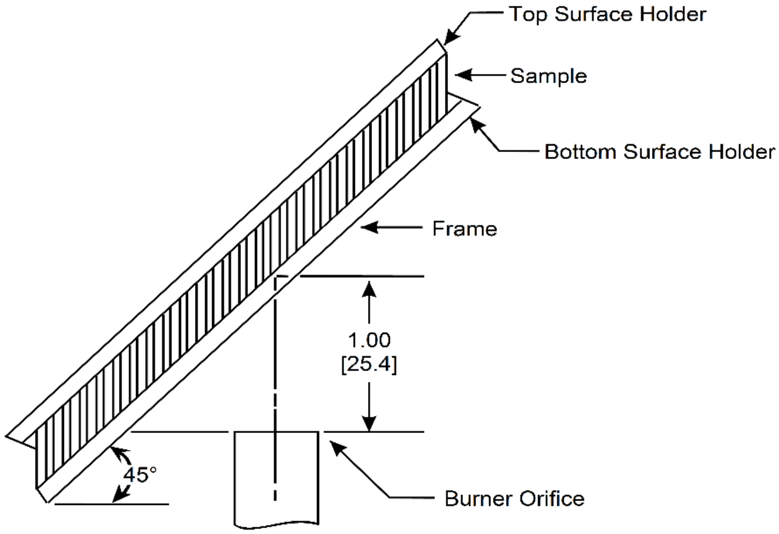


Figure C1-3. Flame position on 30-second, 45-degree Bunsen burner test sample

C1.6.2.5 Apply the flame for 30 seconds and then withdraw it by moving the burner at least 3 inches away from the sample or by turning the gas off. Some laboratories turn the gas off on completion of the test; however, the majority of test facilities, including the original equipment manufacturers (OEMs), withdraw the flame by moving the burner away from the sample.

C1.6.2.6 Determine the flame time for the sample.

C1.6.2.7 Determine the glow time for the sample.

C1.6.2.8 Determine if flame penetration occurs.

C1.6.2.9 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 of smoke and fumes. Remove any material from the bottom of the cabinet that fell from the sample. The operator should refer to the facility's safety manual for further information dealing with smoke and flammability byproducts.

C1.6.2.10 If necessary, clean the test cabinet window prior to testing the next sample.

C1.7 Report

C1.7.1 Material Identification

Fully identify the material tested, including thickness.

C1.7.2 Flame Time

Report the flame time for each sample and determine and record the average flame time for all samples tested.

C1.7.3 Glow Time

Report the glow time for each sample tested to the nearest second. Determine and record the average glow time for all samples tested.

C1.7.4 Flame Penetration

Report whether the Bunsen burner flame penetrated the sample for each sample tested.

C1.8 Requirements

C1.8.1 Flame Time

The average flame time for all samples tested will not exceed 15 seconds.

C1.8.2 Flame Penetration

The Bunsen burner flame will not penetrate any of the samples tested.

C1.8.3 Glow Time

The average glow time for all samples tested will not exceed 10 seconds.

Chapter C2
Oil Burner Test for Cargo Liners

C2.1 Scope

C2.1.1 Applicability

This test method evaluates the flame-penetration resistance capabilities of aircraft cargo compartment lining materials using a high-intensity open flame to show compliance to the requirements of 14 CFR 25.855.

C2.2 Definitions

C2.2.1 Burnthrough

Burnthrough is defined as flame penetration of the test sample or the development of a visible breach, opening, gap, fissure, or any void through which a flame penetrates during the test. The development of any such void that allows burnthrough during the test period shall be cause for failure.

C2.2.2 Test Sample

A test sample consists of a ceiling (horizontal) and sidewall (vertical) cargo liner panel installation. A sample may also consist of a cargo liner panel installation (ceiling or sidewall) and fire-resistant baffle (see section C2.4.1.1 for details).

C2.3 Apparatus

C2.3.1 Test-Sample Apparatus

The test-sample apparatus includes the test-sample mounting frame (see figure C2-1), a sidewall (vertical) test-sample retaining frame (see figure C2-2), and a ceiling (horizontal) test-sample-panel retaining frame (figure C2-3). Test-sample panels are placed between the mounting frame and retaining frames. The test-sample apparatus must allow movement of the test sample so it can be positioned above the burner at the proper distance (see figure C2-4). It is recommended that the test-sample-apparatus have the capability of being positioned a minimum of 36 inches (914.4 mm) from the burner cone to prevent preheating of the sample during the burner warmup period.

NOTE: The sample frame may be positioned closer to the burner cone during warmup but may create a more severe test condition.

C2.3.1.1 Test-Sample Mounting Frame

The test-sample mounting frame will be fabricated of 1- by 1- by 0.125-inch (25- by 25- by 3-mm) stainless-steel angle and bolts as shown in figure C2-1. The frame is symmetrical with respect to the dimensions and position of the bolts. The bolts are positioned on the centerline of the angle iron and welded into position. The test-sample panels are mounted to the outer surfaces of the sample mounting frame.

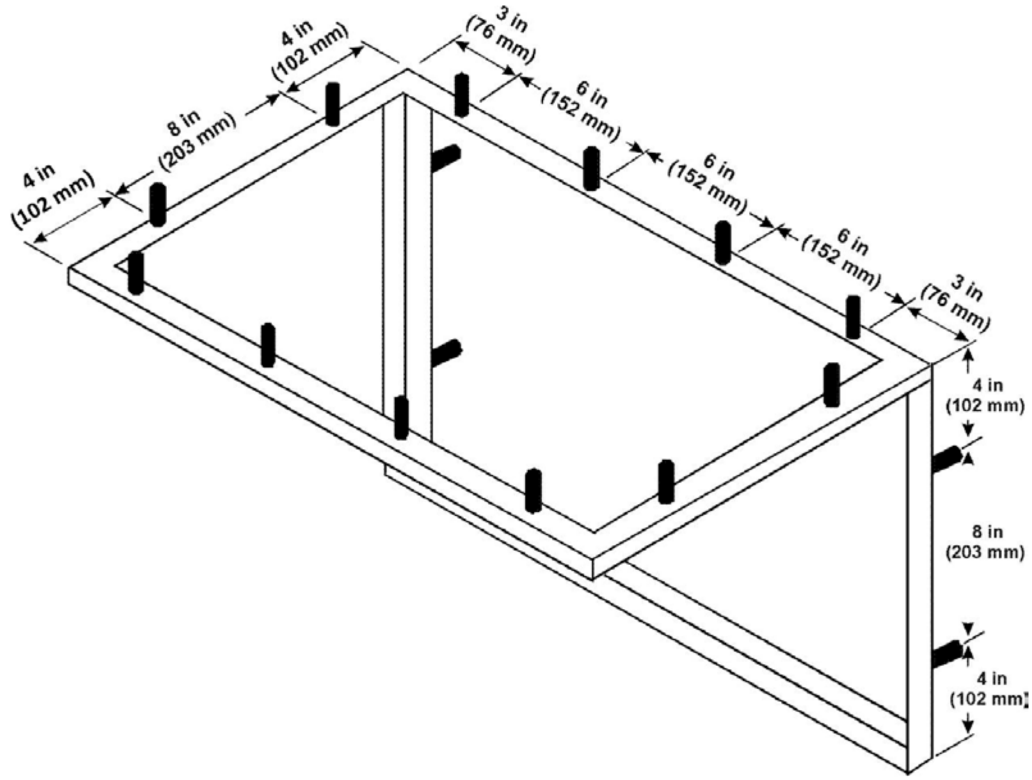


Figure C2-1. Test-sample mounting frame

C2.3.1.2 Test-Sample Retaining Frame

Two test-sample retaining frames are required: one for the sidewall (vertical) test panel (see figure C2-2) and one for the ceiling (horizontal) test panel (see figure C2-3). Each test-sample retaining frame will be fabricated of a 1- by 1- by 0.125-inch (25- by 25- by 3-mm) stainless-steel angle with holes machined, as shown in figure C2-2. The machined holes should be sized accordingly to fit over the bolts on the test-sample mounting frame. The ceiling (horizontal) retaining frame requires additional 1- by 1- by 0.125-inch (25- by 25- by 3-mm) stainless-steel angle components for mounting a 0.625-inch diameter thermocouple, as shown in figure C2-3. The retaining frames are placed on the outside of the test-sample mounting frame with the test-sample panels clamped between the mounting and retaining frames. Hex nuts or similar fasteners will be used in combination with the bolts on the mounting frame to secure the retaining frames and prevent the sample panels from slipping or pulling away from between the frames during testing.

NOTE: Clamps may be used to secure the retaining frames to the sample mounting frame for some test-sample configurations. Ensure the clamps are secured sufficiently to prevent visible gaps between the frames and sample panels, and prevent the sample panels from slipping or pulling away from between the frames during testing.

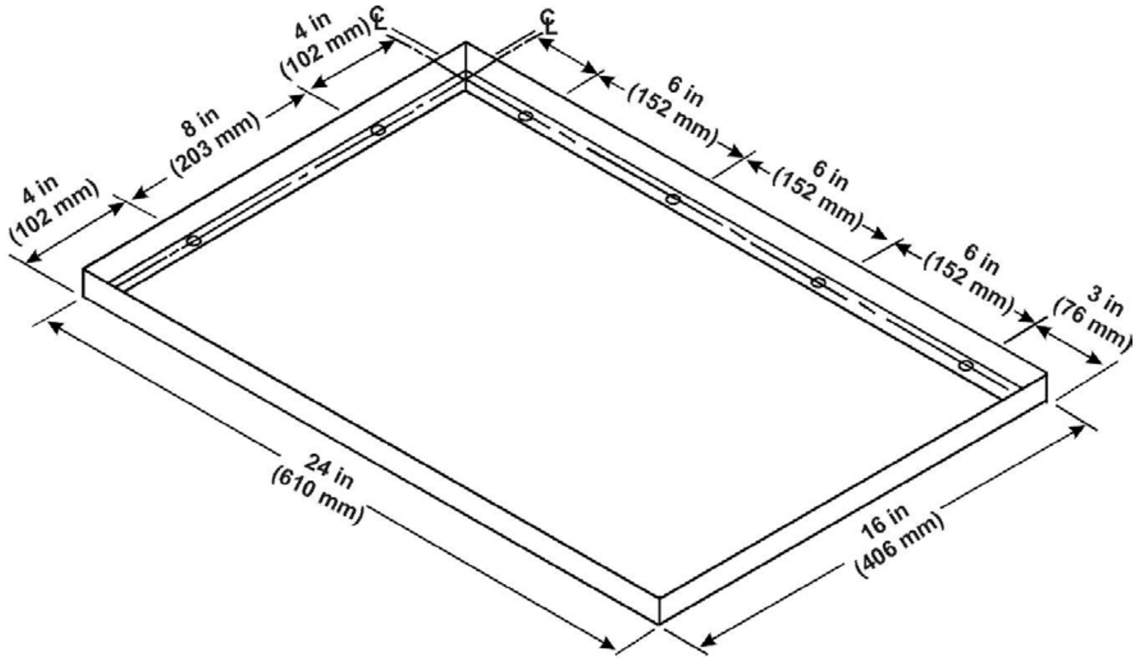


Figure C2-2. Cargo liner test vertical sample panel retaining frame

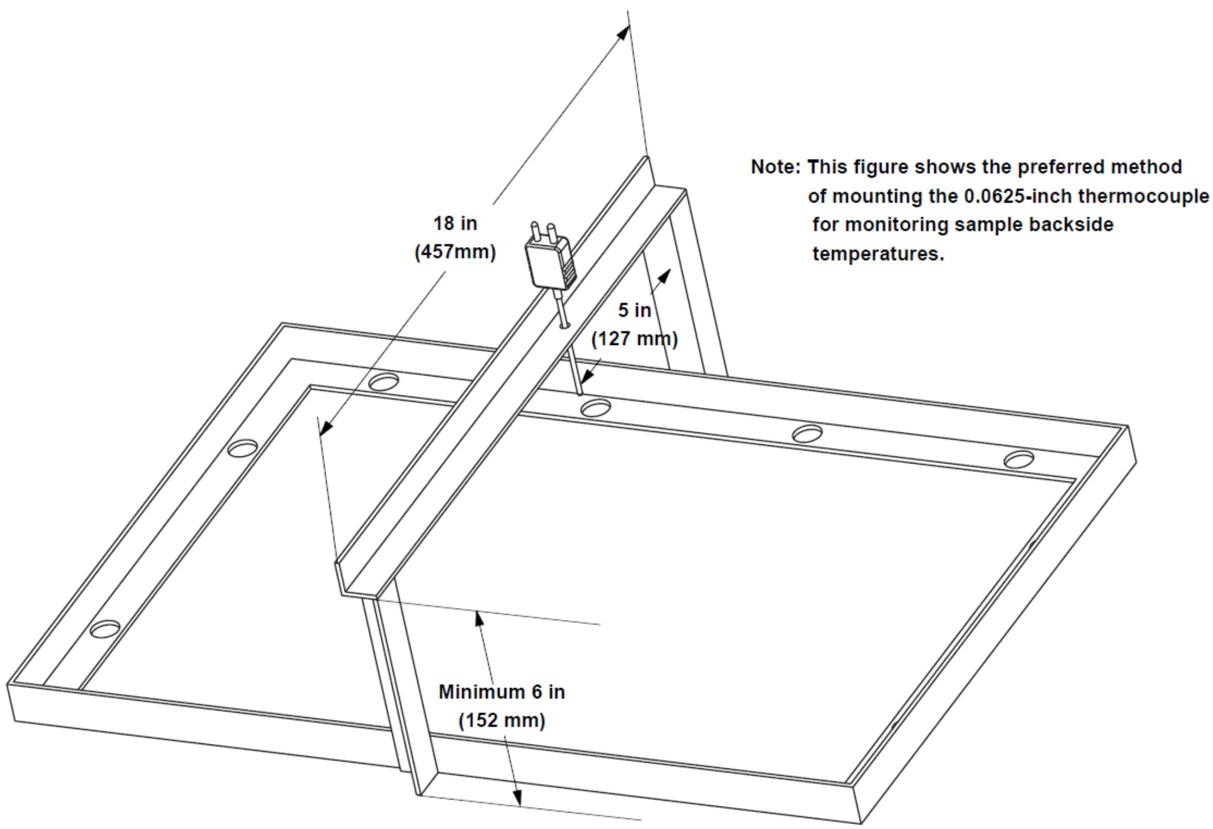


Figure C2-3. Cargo liner test horizontal sample panel retaining frame

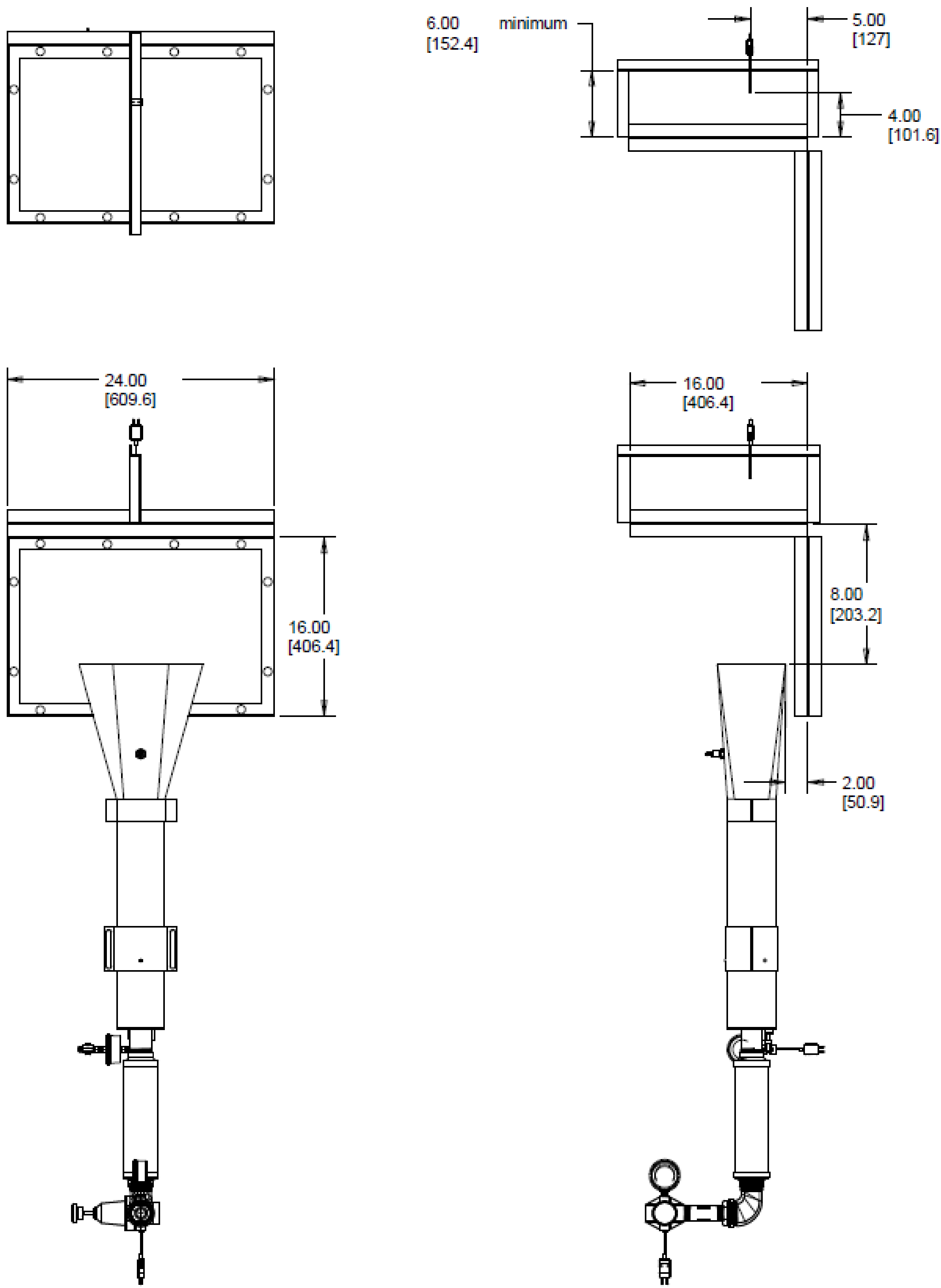


Figure C2-4. Test-sample apparatus and sonic burner in the test position

C2.3.2 Burner

The test burner is the Sonic Fire Test Burner, described in detail in appendix K. The burner configuration for this test method is displayed in table C2-1.

Table C2-1. Burner configuration for the cargo liner flammability test

Fuel	Nozzle	2.0 gal/hr 80° Solid Spray
	Volumetric Flow Rate (gal/hr)	2.0 ± 0.1
	Pressure (psig)	110 ± 10
Air	Diffusion Method	Stator and Turbulator
	Pressure (psig)	45 ± 1
	Mass Flow Rate (SCFM)	54.2
	Burner Orientation	Vertical

C2.3.2.1 Inlet-Condition Measuring

To obtain an accurate measurement of the conditions entering the burner, the fuel pressure and temperature, and the air pressure and temperature measurements must be made nearest to the burner inlet (see figure C2-5). To minimize air-stream disruptions, the intake air temperature must be measured prior to the sonic nozzle.

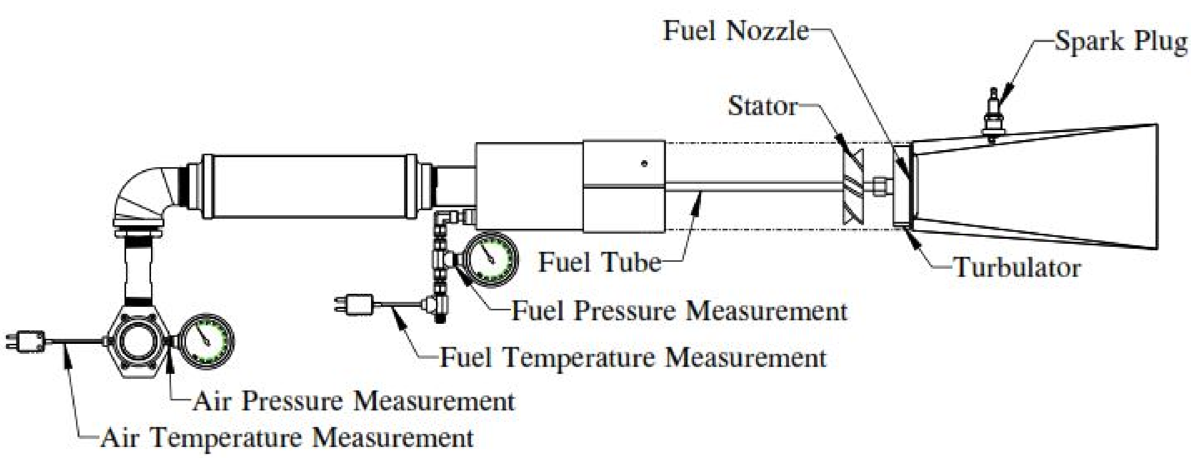


Figure C2-5. Inlet-condition measurement location (side view)

C2.3.2.2 Fuel Nozzle

A screw-in fuel nozzle is required to maintain a fuel pressure that will yield a 2 ± 0.1-gal/hr (7.57 L/hr ± 0.38 L/hr) fuel flow. A nozzle with an 80-degree solid spray angle nominally rated at 2.0 gal/hr (7.57 L/hr) at 100 lb/in^2 (0.69 MPa) has been found to deliver the appropriate flow rate and produce the proper flame pattern. Actual flow rate measurements may deviate from the advertised flow rate. The actual flow rate must be measured manually using a flexible tube, graduated cylinder, and timing device, as described in section C2.5.4.6. The fuel pressure must then be adjusted accordingly to produce the required fuel flow of 2 ± 0.1 gal/hr (7.57 L/hr ± 0.38 L/hr). For more details, refer to appendix K, section K.3.4.4, Fuel Nozzle.

C2.3.2.3 Fuel-Pressure Regulation

The fuel must be properly pressurized to deliver the proper fuel flow. Ideally, this pressure must be in the range of 100–120 lb/in^2 (0.69 to 0.83 MPa). For details on fuel pressurization and regulation, refer to appendix K, section K.3.4, Fuel System.

C2.3.2.4 Fuel Type

A kerosene-type fuel is used in the burner equipment. Jet A and JP-8 (military equivalent to Jet A) fuel is recommended; however, other fuels are permissible if the flame temperature can be maintained according to section C2.6.1.3. For more details, refer to appendix K, section K.3.4.6, Fuel.

C2.3.2.5 Burner Cone

A 12 ± 0.125-inch (305 ± 3-mm) burner extension cone is fitted to the end of the burner draft tube. The opening must be 6 ± 0.125 inches (152 ± 3 mm) high and 11 ± 0.125 inches (280 ± 3 mm) wide. For more details, refer to appendix K, section K.3.7, Burner Cone.

C2.3.2.6 Spark Plug

An automotive-style spark plug is fitted into a threaded boss, which is welded to the burner extension cone. The threaded boss is centered on the upper surface of the burner cone, at a distance of 6 ± 0.125 inches (152 ± 3 mm) from the intake end of the burner cone. For more details, refer to appendix K, section K.3.5, Ignition System.

C2.3.3 Burner Flame Consistency Validation Thermocouples

Seven thermocouples must be used to check the flame temperature of the burner. The thermocouples must be 0.125-inch (3.2 mm) in diameter, insulation packed, 310 stainless-steel sheathed, type K (chromel-alumel), grounded junction with a nominal 24 American Wire Gauge (AWG) size conductor. Thermocouples purchased with a certificate of calibration may provide more accurate readings but are not required. The seven thermocouples must be attached to a steel mounting plate to form a thermocouple rake for placement above the burner cone during the burner-flame consistency validation procedure (see figure C2-6). It is recommended the thermocouple mounting plate be a minimum of 8 inches (203 mm) away from the tips of the thermocouples.

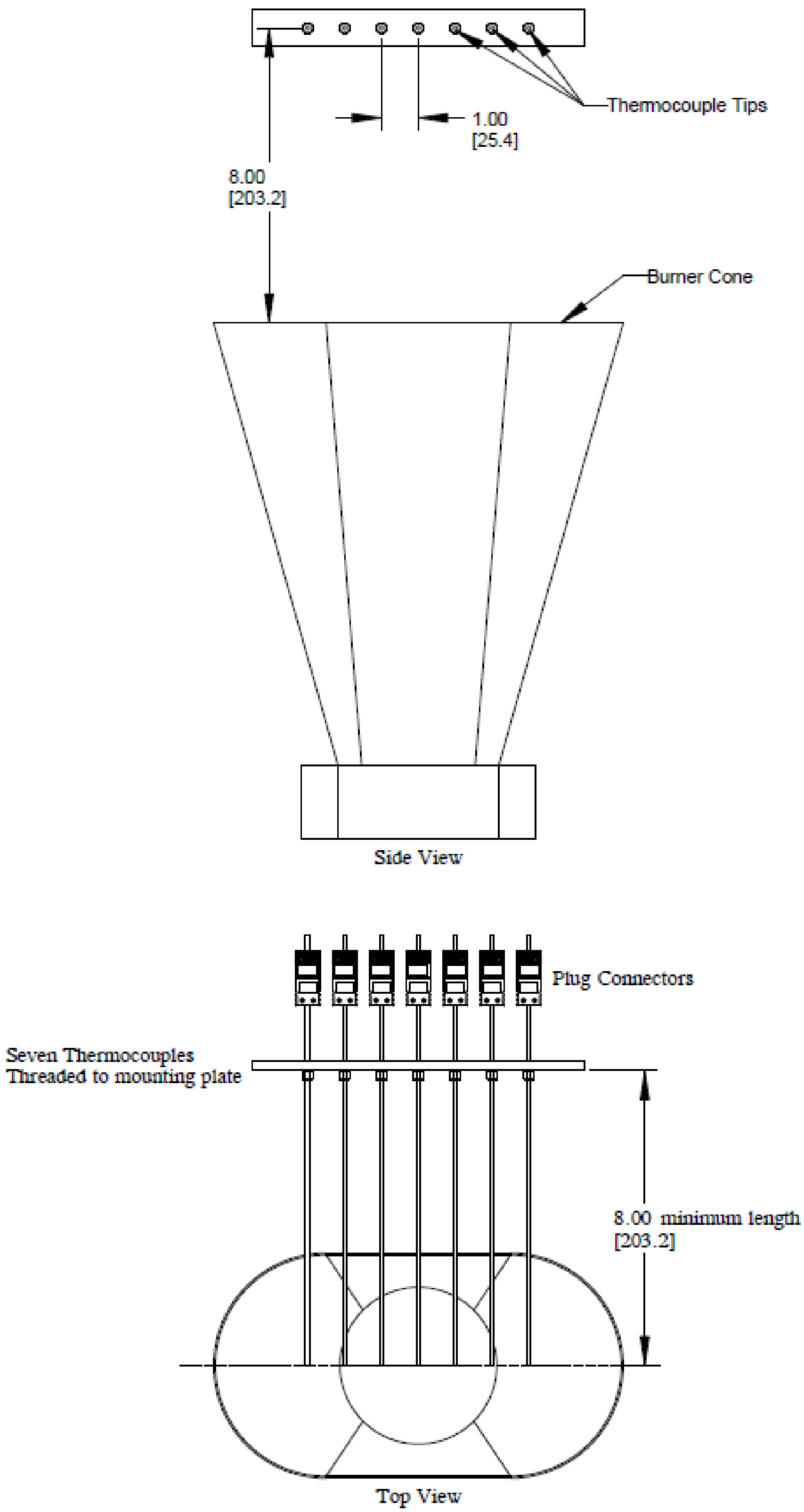


Figure C2-6. Side and top view of thermocouple rake bracket

C2.3.4 Instrumentation and Supporting Equipment

C2.3.4.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the outputs of the thermocouples.

C2.3.4.2 Sample Backside Temperature Thermocouple

A thermocouple will be used to monitor the temperature above the ceiling (horizontal) panel during cargo liner sample testing. The thermocouple must be 0.0625-inch (1.6 mm) in diameter, insulation packed, 310 stainless-steel sheathed, type K (chromel-alumel), grounded junction with a nominal 30 AWG size conductor. The thermocouple tip should be a minimum of 2 inches (51 mm) away from any hardware used to mount the thermocouple in the test position.

C2.3.4.3 Timing Device

A stopwatch or other device, accurate to within + 1 second per 8 hours (+ 3 sec/day), must be used to measure the time of application of the burner flame, the material flaming time, and the burnthrough time.

C2.3.4.4 Test Chamber Anemometer

A handheld vane-type or hotwire-type air velocity-sensing unit capable of measuring accurately in the 0–100 ft/min range must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating. Airflow measurements should be taken at the beginning of the day prior to operating the test burner. A suitable hotwire anemometer, which may be mounted to the sample test frame, is manufactured by Dwyer Instruments, model number 641-6-LED. A suitable handheld hotwire anemometer is manufactured by TSI, model number 9515. Vane-type anemometers typically do not function properly with airflow rates less than 50 ft/min.

C2.3.4.5 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. Although not required, the recommended minimum of the test-chamber floor area is 15 feet by 15 feet (4.57 m by 4.57 m) or larger.

NOTE: Smaller test cells may experience significant increases in ambient air temperature while testing. This may increase the severity of the test.

C2.3.4.6 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

C2.4 Test Samples

C2.4.1 Sample Configuration

Each cargo-liner panel type and design configuration will be tested. Design configuration includes cargo-compartment design features, such as corners, joints, seams, lamp assemblies, pressure-relief valves, and temperature sensors that may affect the capability of a cargo compartment to safely contain a fire (see section C2.7.9).

C2.4.1.1 Testing Ceiling or Sidewall Panels Individually

Ceiling and sidewall liner panels may be tested individually if a baffle of fire-resistant material, such as Superwool® or Marinite®, is used to simulate the missing panel.

C2.4.2 Sample Number

A minimum of three samples for each sample type or design configuration will be prepared for testing.

C2.4.3 Sample-Panel Size

Each sample panel to be tested will measure 16 ± 0.125 inches (406 ± 3 mm) by 24 ± 0.125 inches (610 ± 3 mm).

C2.4.4 Sample Conditioning

Samples will be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing. Remove only one sample at a time from the conditioning environment immediately before testing.

C2.5 Preparation of Apparatus

C2.5.1 Alignment

Mount a test sample on the test-sample frame. Level and center the sample-holder frame assembly to ensure alignment with the burner cone. Move the test-sample mounting frame into position in front of the burner, and check for proper alignment (i.e., distance from exit of burner cone to face of test sample, proper sample height with respect to cone centerline). The movable assembly should incorporate mechanical stops or detents to ensure that the samples can be moved into position quickly without measurement during testing.

C2.5.2 Chamber Ventilation

Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. With the test sample still in place on the test frame, measure the airflow in the test chamber using a hotwire anemometer or equivalent measuring device. The vertical air velocity within a 12-inch (30.5 cm) radius from any point on the test sample must be less than 100 ft/min (50.8

cm/sec). The horizontal air velocity within a 12-inch (30.5 cm) radius from any point on the test sample must be less than 50 ft/min (25.4 cm/sec).

NOTE 1: Airflow measurements do not have to be taken for each sample tested. It is recommended that airflow measurements be taken at the beginning of the day before testing, and at the end of the day when testing is completed.

NOTE 2: Personnel present within the test cell may influence air-velocity readings. This may be avoided by mounting the anemometer instrumentation to the sample mounting frame during test cell air-velocity measurements.

C2.5.3 Test-Chamber Air Temperature

The temperature of the test chamber should be between 50°F and 100°F (10°C and 38°C) before the start of each test. The chamber air temperature should be measured at the same height as the ceiling (horizontal) test-sample panel, within 12 inches (30.5 cm) laterally. Remove the sample from the test frame. Do not use this sample for testing. The sample may be kept for future test-chamber airflow and temperature measurements.

C2.5.4 Sonic Burner Configuration

C2.5.4.1 Fuel-Nozzle Location

The tip of the fuel nozzle, or fuel exit plane, must be located 0.1875 ± 0.020 inch (4.763 ± 0.5 mm) from the exit plane of the turbulator (see figure C2-7).

C2.5.4.2 Stator Adjustment

The stator is positioned by adjusting its translational position and its axial position on the fuel rod.

C2.5.4.2.1 Stator Translational Position

The front face of the stator must be located 2.6875 ± 0.020 inches (68.263 ± 0 mm) from the exit plane of the turbulator (see figure C2-7). This stator translational position is also 2.5 inches (63.5 mm) from the tip of the fuel nozzle.

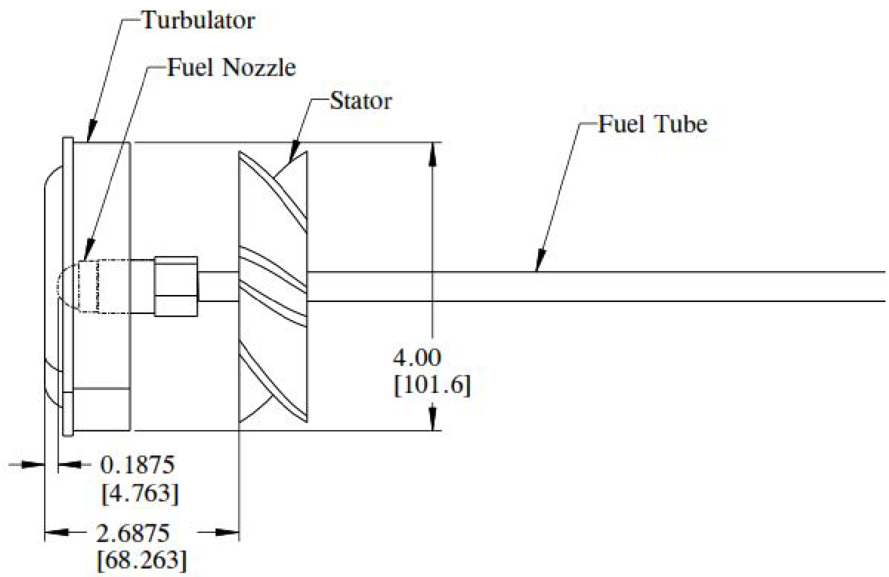


Figure C2-7. Fuel nozzle and stator locations

C2.5.4.2.2 Stator Axial Position

The line running through the geometric center of the stator and traversing through the center of the stator set screw can be used as a reference for properly orienting the rotational position of the stator. The stator must be positioned so the reference angle is 0 degrees (12 o'clock) from the zero position (see figure C2-8).

NOTE: The 0-degree reference angle is pointed at, and perpendicular to, the inner surface of the sidewall (vertical) sample panel. The stator set screw will be oriented toward the vertical panel, whereas the notch in the turbulator will be oriented away from the vertical panel.

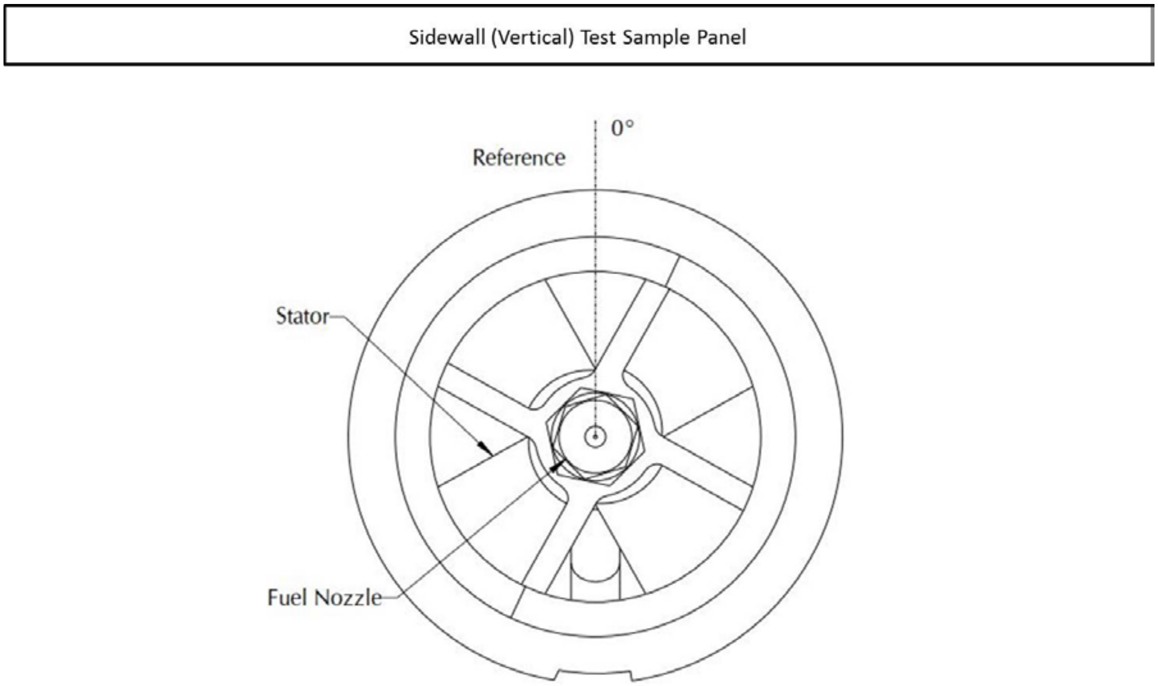


Figure C2-8. Stator axial position viewed from above draft tube and turbulator

C2.5.4.3 Spark Plug

A high-voltage oil burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone.

C2.5.4.3.1 Spark Plug Gap

The spark plug gap (distance) between the two electrodes must be 0.100 inch (2.5 mm), as shown in figure C2-9.

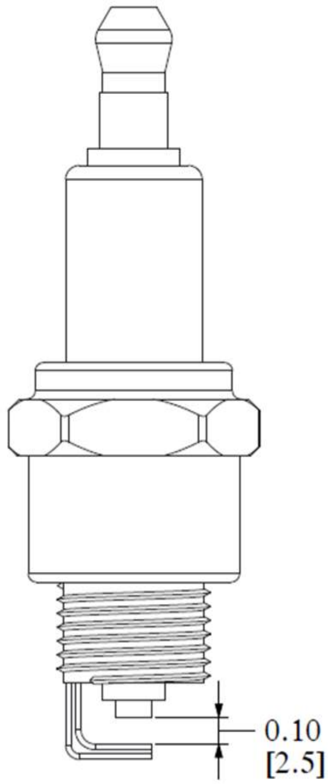


Figure C2-9. Spark-plug gap measurement

C2.5.4.4 Spark-Plug Wire Routing

The length and arrangement of the spark-plug wire must be monitored to prevent heat damage during flame temperature validation and testing. Once the burner is ignited, the outside surface temperature of the burner cone will increase rapidly, becoming capable of damaging the wire if it comes in contact with the cone. The spark-plug wire should be carefully routed to prevent contact with the cone or other hot surfaces, and should also be shielded in a heat-resistant covering to further protect it from convective heat damage from the burner flames. The wire can be routed as shown in figure C2-10, in which it does not contact any components in the vicinity of the burner cone.

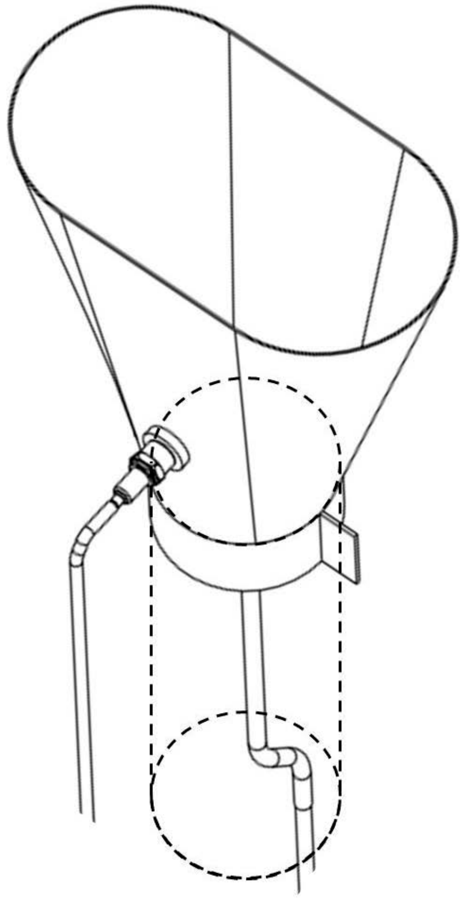


Figure C2-10. Proper routing of the spark-plug wire

C2.5.4.5 Volumetric Airflow Control

The volumetric airflow is controlled by a regulated sonic nozzle. Adjust the upstream supply air pressure to 45 ± 1 lb/in^2 (0.31 ± 0.007 MPa). The intake air temperature must be maintained within the range of 40°F–60°F (4°C–16°C). For more details, refer to appendix K, section K.3.2, Combustion Air Control.

C2.5.4.6 Fuel-Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon tubing and appropriately sized graduated cylinder. Slip the Tygon tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon tubing into a small bucket or other collection basin. Turn on the fuel solenoid, making sure the ignition system is off. After establishing a steady stream of fuel flow, simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Do not disturb or move the tube while collecting fuel in the graduated cylinder. Collect the fuel for a 2-minute period, making certain to immediately remove the graduated cylinder from the fuel stream at precisely 2 minutes. Calculate the flow rate, and ensure that it is 2 ± 0.1 gal/hr (7.57 ± 0.38 L/hr). If the flow rate is not within the tolerance, adjust the fuel pressure accordingly. Record the fuel pressure necessary to achieve the required fuel flow. The recorded fuel pressure must be monitored and maintained during burner operation, and fluctuate no more than ± 2 lb/in^2 (± 0.0138 MPa) during flame-consistency validation and sample testing. A flame temperature validation or sample test will be void should the fuel pressure fluctuate outside of this range during either procedure. The temperature of the fuel must be maintained within the range of 32°F–52°F (0°C –11°C).

NOTE: Because of the vertical orientation of the cargo liner test burner, the tube may need to fill with fuel directly above the fuel nozzle before a steady stream of fuel will flow freely from the tube end. It is recommended the fuel flow steadily from the tube end for a minimum 10-second period before collecting fuel in the graduated cylinder.

C2.6 Burner Flame Consistency Validation

C2.6.1 Sonic Burner

The sonic burner used in the test must be checked to ensure the proper flame temperature is being produced for consistent and accurate test results.

C2.6.1.1 Move the test-sample apparatus from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of combustion products and soot. Soot buildup inside the cone may affect the flame characteristics and cause flame temperature validation difficulties. Check to ensure the burner-cone dimensions are within specified tolerances before flame validation.

C2.6.1.2 Mount the thermocouple rake on a movable stand that is capable of being quickly translated into position in front of the burner. Move the rake into the flame-validation test position and check the distance of each of the seven thermocouples to ensure that they are located 8 ± 0.125 inches (203 ± 3 mm) from the horizontal plane of the burner cone exit. Ensure that the horizontal centerline of the thermocouples is directly above the horizontal centerline of the burner cone (see figure C2-6). Place the tip of the center thermocouple (thermocouple number 4) above the center of the burner cone exit. Note that the movable thermocouple rake stand must incorporate detents that ensure proper centering of the thermocouple rake with respect to the burner cone, so that rapid positioning of the rake can be achieved during the validation procedure. Once the proper position is established, move the thermocouple rake away and move back into the flame-temperature validation position to recheck distances. When all distances and positions are confirmed, move the thermocouple rake away from the burner.

C2.6.1.3 While the thermocouple rake is away from the burner, turn on the igniters, pressurized air, and fuel flow, and light the burner. Allow the burner to warm up for 2 minutes. After warmup, move the thermocouple rake into position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for 30 seconds. Remove the thermocouple rake from the flame-temperature validation position, and turn off the burner. Calculate the average temperature of each thermocouple over this period and record. Although not a requirement for testing, the recommended average temperature of each of the seven thermocouples should be 1700°F + 100°F (927°C + 55°C). The burner should be rechecked to ensure it is configured properly if temperatures are measured outside of this recommended range. A flame that appears biased to one side or produces significantly higher temperatures on one end of the flame validation thermocouple rake may indicate that an adjustment of the fuel nozzle/ internal stator orientation/distance from the end of the draft tube may be necessary if the adjustments remain within allowable tolerances. If no problems are found with the burner, any thermocouple reading outside of this range may require replacement. It is recommended that the burner flame temperature be validated at the beginning and end of each day testing is performed.

NOTE 1: The thermocouples are subjected to high-temperature durations during calibration. Because of this type of cycling, the thermocouples may degrade with use. Small but continuing decreases or extreme variations in temperature, or no temperature reading at all, are signs that the thermocouple or thermocouples are degrading, or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

NOTE 2: The sonic burner is sensitive to proper alignment of the fuel nozzle. It is crucial that the fuel nozzle be aligned to the geometric center of the turbulator. A slight adjustment of the fuel tube between the stator and fuel nozzle may be required to obtain an even temperature profile across the thermocouple rake. The center point of the nozzle where the fuel exits should not deviate more than 0.0625 inch from the geometric center of the turbulator exit plane when looking into the burner draft tube. This should be performed only after checking the burner for proper configuration.

C2.7 Test Procedure

C2.7.1 Examine and clean the cone of soot deposits and debris. Remove any debris or remains of prior test samples from the test-sample frames.

C2.7.2 Position the test-sample panels in the appropriate locations on the sample mounting frame. Place the two sample retaining frames over the sample panels and secure the retaining frames to the sample mounting frame. Move the sample frame assembly into the test position.

C2.7.3 Mount the backside temperature thermocouple tip 4 ± 0.125 inches (102 ± 3 mm) above the top surface of the ceiling (horizontal) sample test panel and align with the center of the burner cone exit. Verify the ceiling (horizontal) test frame is level.

C2.7.4 Move the sample frame assembly away from the burner to the standby position so the flame does not impinge on the test sample during the warmup period. Turn on the burner and allow it to stabilize for 2 minutes.

C2.7.5 Begin the test by moving the test-sample apparatus into the test position, and start the timing device when the sample is fully in the test position.

C2.7.6 Record the temperature measured by the sample backside thermocouple at least once a second for the duration of the test.

C2.7.7 Expose the sample to the flame for 5 minutes or until flame penetration occurs.

C2.7.8 Turn off the burner to terminate the test.

C2.7.9 The following sections present testing procedures for patch repairs, seams, joints, fastening systems, lighting fixtures, and corners.

C2.7.9.1 Patch Repairs

Reference FAA Advisory Circular (AC) 25.855-1 for details on the proper testing of patch repairs.

C2.7.9.2 Seams, Joints, Fastening Systems, Lighting Fixtures, and Corners

The barrier material used for design features, such as recessed lighting fixtures and pressure-relief valves, will be tested in the same manner as a cargo liner sample. Seams, joints, and fasteners in the ceiling position will be tested longitudinally, extending the length of the liner and centered over the burner cone. Seams or joints used on the sidewall will be positioned longitudinally, 2 inches from the top of the vertical test-sample panel, as representative of the aircraft application. Apply the test procedures in sections C2.7.1 through C2.7.8 to test these design features.

C2.8 Report

C2.8.1 Report the number of samples tested and a complete description of the material(s) being tested, including manufacturer and thickness.

C2.8.2 Report the orientation of the panels tested (i.e., ceiling/sidewall).

C2.8.3 Record any observations regarding the behavior of the test sample during flame exposure, such as delamination, resin ignition, smoke, and the time each event occurred.

C2.8.4 Report the time of occurrence of flame penetration, if applicable, for each of the samples tested.

C2.8.5 If flame penetration does not occur, report the maximum temperature measured by the sample backside thermocouple and time of occurrence.

C2.8.6 Provide a record of flame-temperature validation.

NOTE: Although not required, it may be useful to record the date, time, ambient air temperature, humidity level, and any other data that may be used to study the burn characteristics of the samples.

C2.9 Requirements

C2.9.1 None of the three samples tested will burn through within the 5-minute flame exposure.

C2.9.2 None of the three samples tested will exceed 400°F (204°C) measured by the backside temperature thermocouple during flame exposure.

C2.9.3 For the patch adhesion test, the patch must be intact after the 5-minute flame exposure for each of the three samples.

C2.9.4 If one or more samples fail to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of samples meets the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but have experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.

C2.9.5 Samples that pass in the ceiling orientation may be used as a sidewall panel without further tests.

NOTE: Flames may appear on the outer surface of the test sample resulting from the ignition of flammable smoke/gases produced from the sample when subjected to the burner flame. This does not constitute burnthrough. Burnthrough occurs only if the flame from the burner passes through the sample material. Whereas there are no specific requirements related to backside burning, more than 60 seconds of burning on the sample backside is indicative of a less-reliable material. However, the sample material is considered to be a failure if the 400ºF criteria are exceeded.

CHAPTER D: OTHER FLAMMABILITY TESTS

Chapter D1
Horizontal Bunsen Burner Test for Cabin, Cargo Compartment, and Miscellaneous Materials

D1.1 Scope

D1.1.1 Applicability

This test method is intended for use in determining the resistance of materials to flame when tested according to the 15-second horizontal Bunsen burner tests specified in 14 CFR 25.853.

D1.2 Definitions

D1.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. For this test, the ignition time is 15 seconds. Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

D1.2.2 Burn Rate

Burn rate is the rate at which a flame front moves over a specified distance on a test specimen under specified test conditions. In this test, it is the rate with which a flame front moves across a test specimen mounted horizontally.

D1.3 Apparatus

D1.3.1 Test Cabinet

Tests will be conducted in a draft-free cabinet fabricated in accordance with figures D1-1 to D1-3 or other equivalent enclosures acceptable to the 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.

NOTE: 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.

NOTE: “Draft free” implies a condition of no air currents in a closed 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 to close the door and observe the behavior of the smoke for signs of drafts. A test cabinet other than one fabricated in accordance with figures D1-1 to D1-3 may be found to be acceptable after review by the FAA.

NOTE: 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.

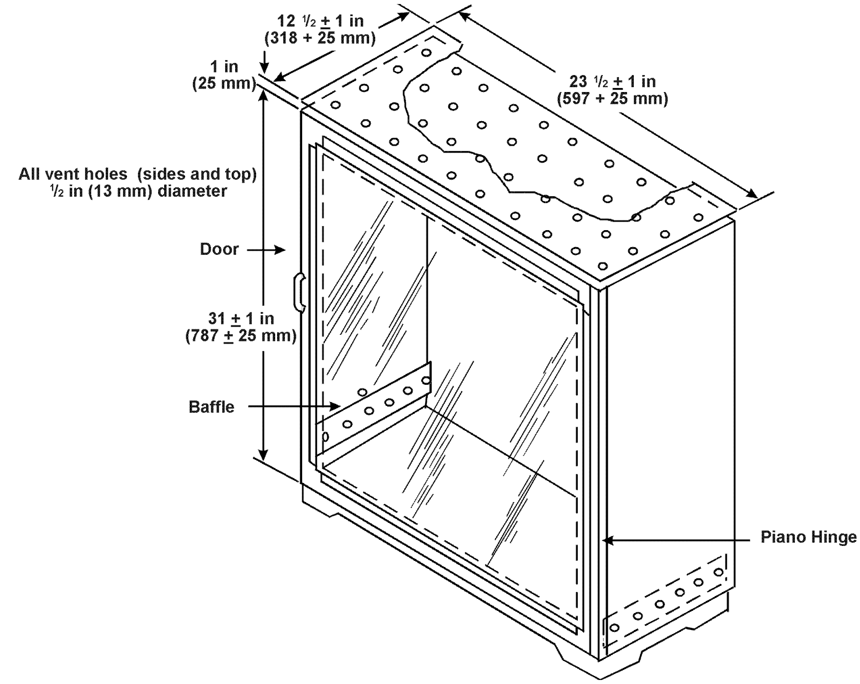


Figure D1-1. Sketch of horizontal Bunsen burner test cabinet

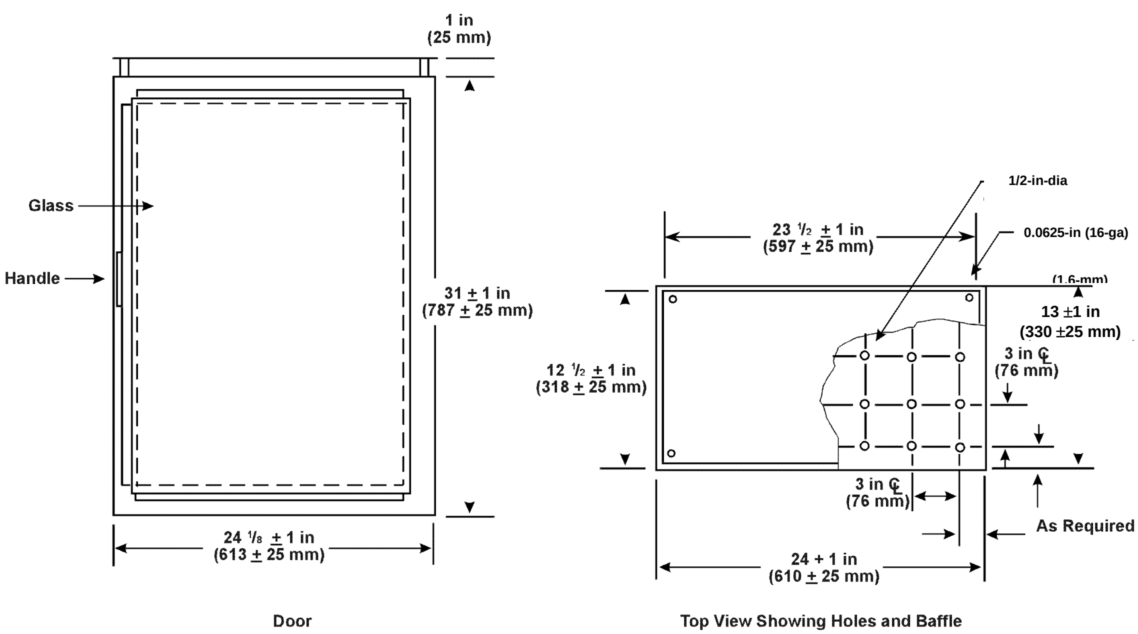


Figure D1-2. Front and top view of horizontal Bunsen burner test cabinet

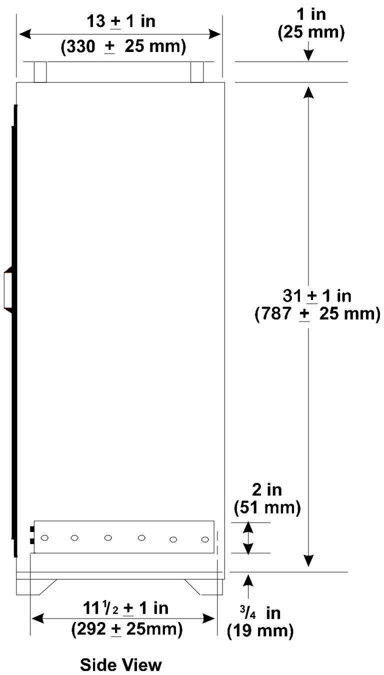


Figure D1-3. Side view of horizontal Bunsen burner test cabinet

D1.3.2 Specimen Holder

A specimen holder fabricated of corrosion-resistant metal in accordance with figure D1-4 will be used. When performing the tests, the specimen will be mounted in the frame so that the two long edges are held securely. The exposed area of the specimen will be 2 inches (51 mm) in width and 12 inches (305 mm) in length.

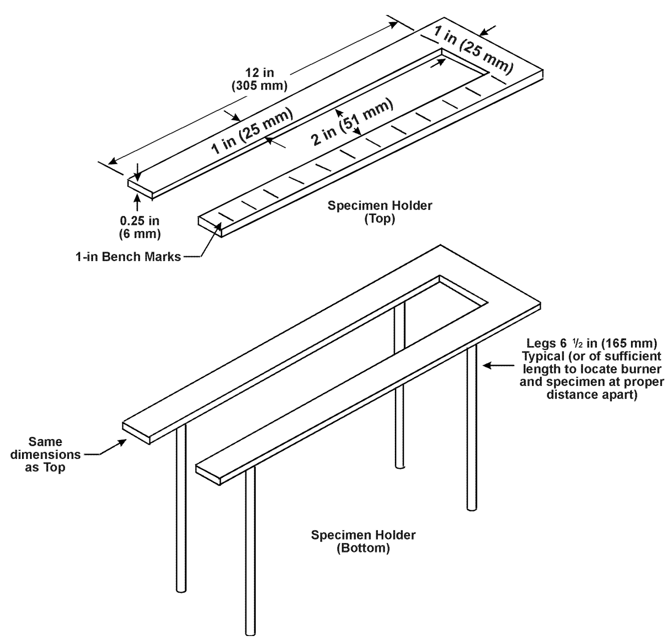


Figure D1-4. Horizontal Bunsen burner test specimen holder

D1.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 0.375-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.

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

D1.3.3.1 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 (i.e., a pure diffusion flame may be used). 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 AWG thermocouple.

NOTE: B-gas, which is the burner fuel specified in Federal Test Method 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 pentcarbonyl (Fe(CO)5), which is volatile and may cause interference with the normal flame characteristics, therefore causing the erratic behavior. Because of its inconsistent flame characteristics, at least if supplied in steel cylinders, B-gas is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

One noteworthy point that should be mentioned is that some labs have experienced sharp decreases in flame temperature after the gas cylinders are approximately three-fourths empty. 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 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. This problem can be eliminated by using a two-stage regulator or adjusting pressure on a single-stage regulator as the cylinder gets low.

D1.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure D1-5. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2.5 ± 0.25 psi (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

D1.3.3.3 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 is spaced 1 inch (25 mm) from the burner barrel, as shown in figure D1-5. 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 the proper flame profile is achieved when the height of the inner cone is 0.875 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long.

NOTE: 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. However, the inner cone of the flame is more visible and easily seen.

D1.3.4 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.

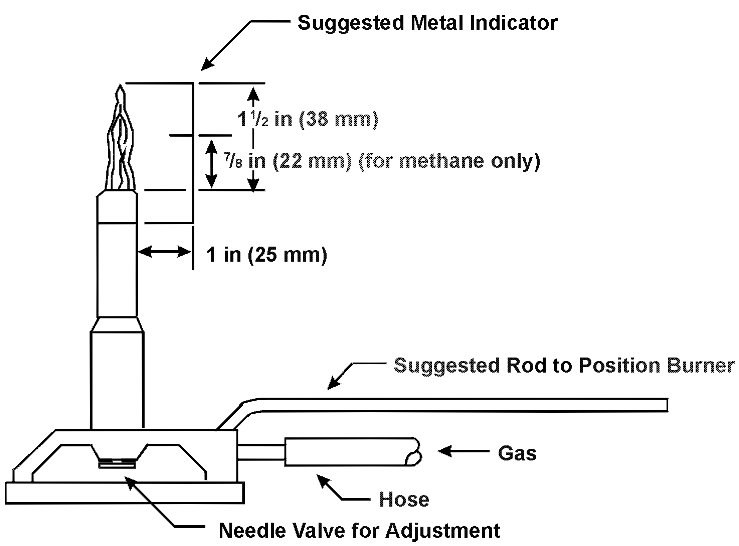


Figure D1-5. Burner plumbing and burner flame height indicator

D1.3.5 Ruler

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) will be provided to measure gauge marks and the flame front position.

D1.4 Test Specimens

D1.4.1 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. Fabricated units, such as sandwich panels, will not be separated into individual component layers for testing.

D1.4.2 Specimen Number

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

D1.4.3 Specimen Size

The specimen will be a rectangle at least 3 by 12 inches (76 by 305 mm), unless the actual size used in the aircraft is smaller. A 3- by 13-inch (76- by 330-mm) specimen can be used to secure the specimen at the end of the specimen holder.

D1.4.4 Specimen Thickness

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

D1.4.4.1 The specimen thickness must be no thicker than the minimum thickness to be qualified for use in the aircraft. The specimen thickness will not exceed 0.125 inch (3 mm).

NOTE: According to 14 CFR 25.853, the specimen must be no thicker than the minimum thickness to be qualified for use in the aircraft. 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.

D1.4.4.2 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. The sheet thickness will not exceed 0.125 inch (3 mm) if the test being run is the 4 inches per minute horizontal burn rate test.

D1.4.5 Specimen Preparation

Mark gauge lines on the back surface (opposite the surface to be exposed to the flame) of the specimen 1.5 inches (38 mm) and 11.5 inches (292 mm) from the end of the specimen that will be subjected to the flame.

D1.4.5.1 A fine-gauge wire mesh with large openings can be used to support test specimens that sag severely during testing so that the flame propagation may be determined accurately.

D1.5 Conditioning

Condition specimens at 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before being tested.

NOTE: As stated in 14 CFR 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 and soot in the air, until the specimen is subjected to the flame.

D1.6 Procedure

D1.6.1 Burner Adjustment

D1.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

D1.6.1.2 Open the stopcock in the gas line fully and light the burner.

D1.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height, in accordance with section D1.3.3.3.

D1.6.2 Test Procedure

D1.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.

D1.6.2.2 Insert the specimen face down (the exposed surface when installed in the aircraft) into the specimen holder so that the end of the specimen from which the 1.5-inch (38-mm) gauge mark was measured is flush with the open end of the specimen holder (see figure D1-6).

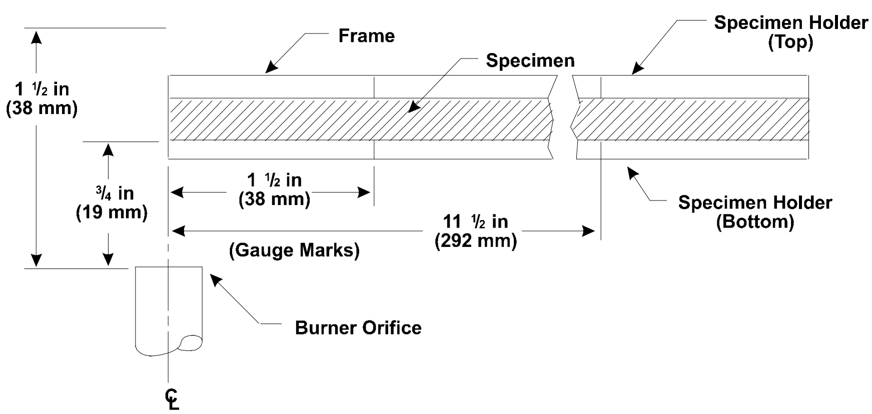


Figure D1-6. Typical burner and specimen location

D1.6.2.3 Close the cabinet door, and keep it closed during the test.

NOTE: It is important that the test be observed carefully while it is being conducted. This applies to all samples.

D1.6.2.4 Start the timer immediately on positioning the burner. Position the burner so that the centerline of the burner orifice is in line with the edge of the specimen holder and the centerline of the width of the specimen (see figure D1-6).

D1.6.2.5 Apply the flame for 15 seconds, and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off.

NOTE: Some laboratories turn the gas off on completion of the test; however, the majority of test facilities, including the OEMs, withdraw the flame by moving the burner away from the specimen.

D1.6.2.6 Note the times/locations on the specimen at which the following events occur:

D1.6.2.6.1 If the flame front crosses the 1.5-inch (38-mm) gauge line, note the elapsed time in seconds, $t_e(1\ 1/2)$, at which the crossing occurs.

D1.6.2.6.2 If the flame front crosses the 11.5-inch (292-mm) gauge line, note the elapsed time in seconds, $t_e(11\ 1/2)$, at which the crossing occurs.

D1.6.2.6.3 If the specimen burns very slowly so that the flame front does not reach the 11.5-inch (292-mm) gauge line within 4 minutes after it passes the 1.5-inch (38-mm) gauge line, note the position in inches, d_f, of the flame front from the ignited end of the specimen and the elapsed time in seconds, $t_e(f)$, then terminate the test.

D1.6.2.7 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 of smoke and fumes. Remove any material that fell from the specimen from the bottom of the cabinet. The operator should refer to the facility's safety manual for further information dealing with smoke and flammability byproducts.

D1.6.2.8 If necessary, clean the test cabinet window prior to testing the next specimen.

D1.6.3 Test Results—Burn Rate

Determine the burn rate as follows:

D1.6.3.1 If the flame front self-extinguished before crossing the 11.5-inch (292-mm) gauge line, record the burn rate as 0.

D1.6.3.2 If the flame crosses the 11.5-inch (292-mm) gauge line, determine and record the burn rate as:

Burn rate (in/min) = 600/ $t_e(10)$, where $t_e(10) = t_e(11\ 1/2) - t_e\ (1\ 1/2)$ = time in seconds for the flame front to burn from the 1.5-inch (38-mm) gauge line to the 11.5-inch (292-mm) gauge line.

D1.6.3.3 If the specimen burned very slowly (see section D1.6.2.6.3), the burn rate may be estimated and recorded as:

Burn rate (in/min) = $60 \times \frac{\left(d_f - 1.5\right)}{\left(t_e(f) - t_e\left(1\,{}^1\!/_2\right)\right)}$

D1.7 Report

D1.7.1 Material Identification

Fully identify the material tested, including thickness.

D1.7.2 Test Results

Report the burn rate from section D1.3.6.3 for each specimen tested. Determine and record the average value for the burn rate.

D1.8 Requirements

D1.8.1 Burn rate

The average burn rate for all the specimens tested will not exceed 2.5 inches/minute for 14 CFR 25.853(b-2) or 4 inches/minute for 14 CFR 25.853(b-3), per Code of Federal Regulations (CFR), Title 14, January 1, 1990.

Chapter D2
60-Degree Bunsen Burner Test for Electric Wire

D2.1 Scope

This test method is intended for use in determining the resistance of electric wire insulation to flame when tested according to the 30-second, 60-degree Bunsen burner test specified in 14 CFR 25.869.

D2.2 Definitions

D2.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. The ignition time for this test is 30 seconds. Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

D2.2.2 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.

D2.2.3 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 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.

D2.2.4 Burn Length

Burn length is the length of damage along the wire above and below the point of burner flame impingement and 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.

D2.3 Apparatus

D2.3.1 Test Enclosure and Setup

Tests will be conducted in a cabinet fabricated of sheet metal, approximately 24 inches (610 mm) high by 12 inches (305 mm) wide by 12 inches (305 mm) deep and open at the front and top. External conditions around the cabinet will be such that the cabinet is draft free during a test, but sufficient airflow will be available for complete combustion. Other cabinets may be used if they are draft free and have enough air to allow complete combustion. It is suggested that the cabinet be located inside an exhaust hood to facilitate removal of smoke and fumes after each test.

NOTE: Draft free implies a condition of no air currents in a closed space. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lit 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 described in section 4.3.1 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.

D2.3.2 Specimen Holder

A specimen holder fabricated of corrosion-resistant metal in accordance with figure D2-1 will be used. The specimen holder will be placed so that the specimen is maintained at an angle of 60 degrees horizontally and is positioned parallel to and 6 inches (152 mm) back from the front of the enclosure.

D2.3.2.1 Clamp and Pulley

The specimen will be attached to the specimen holder by a clamp at the lower end and a pulley or rod at the upper end. The span between the clamp and the rod or pulley will be 24 inches (610 mm).

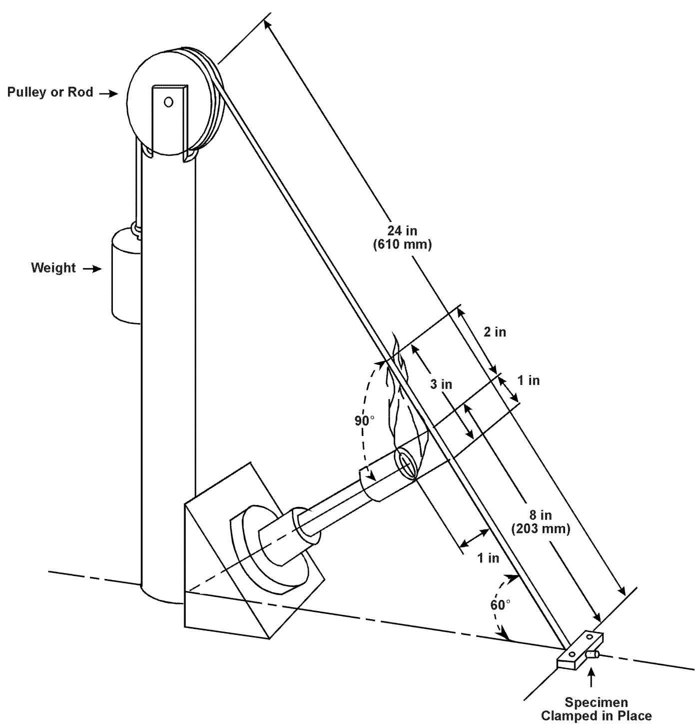


Figure D2-1. 60-degree electrical wire Bunsen burner test setup

D2.3.2.2 Weight

A weight will be attached to the free end of the specimen to keep the specimen taut during the test (see figure D2-1). Suggested weights for various wire sizes are shown in table D2-1.

Table D2-1. Wire size and weight suggestions

AWG	Pounds	Kg
20	0.8	0.4
14	2.0	0.9
8	3.0	1.4
1/0	11.0	5.0

D2.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 0.375-inch (10-mm) inside diameter barrel, and be equipped with a needle valve at the bottom of the burner barrel to adjust the gas-flow rate (see figure D2-2). A means will be provided to move the burner into and out of the test position. Mounting the burner on a fixture that allows it to be rotated in the horizontal plane is suggested.

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

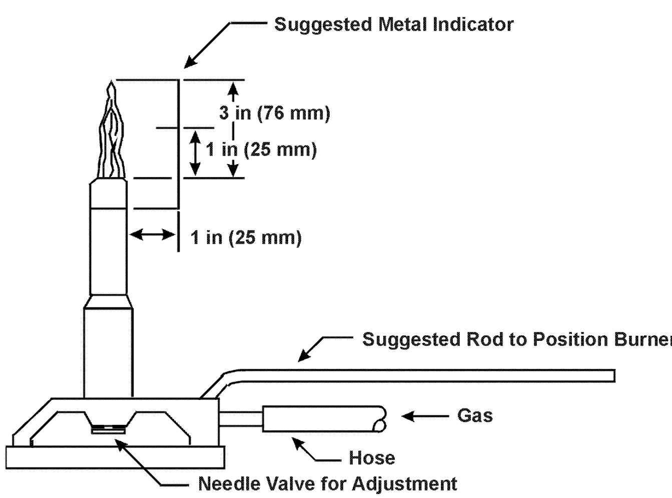


Figure D2-2. Burner plumbing and burner flame-height indicator

D2.3.3.1 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 (i.e., a pure diffusion flame may be used).

Gases such as natural gas and propane can be used as burner fuel. However, it should be required to show compliance with the 1750°F minimum flame temperature using a 24 AWG thermocouple.

NOTE: 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 pentcarbonyl (Fe(CO)5), which is volatile and may cause interference with the normal flame characteristics, therefore causing the erratic behavior. Because of its inconsistent flame characteristics, at least if supplied in steel cylinders, B-gas is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

Some labs have experienced a sharp decrease in flame temperature after approximately three-quarters 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 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. This problem can essentially be eliminated by using a two-stage regulator or adjusting pressure on a single-stage regulator as the cylinder gets low.

D2.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure D2-2. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2 1/2 ± 1/4 lb/ft^2 (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

D2.3.3.3 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 3 inches (76 mm) above the top of the barrel, is attached to the burner barrel, is spaced 1 inch (25 mm) from the burner barrel, and extends above the burner, as shown in figure D2-2. It is desirable to have two prongs to measure 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 this test, it has been determined that the proper flame profile is achieved when the height of the inner cone is 1 inch (25 mm), and the tip of the flame is 3 inches (76 mm).

D2.3.4 Timer

A stopwatch or other device graduated 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.

D2.3.5 Ruler

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

D2.4 Test Specimens

D2.4.1 Specimen Number

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

D2.4.2 Specimen Length

The specimens will be cut to a length of 30 inches (762 mm). The specimen span between the lower clamp and upper pulley or rod will be 24 inches (610 mm).

D2.4.3 Specimen Preparation

Make a gauge mark 8 inches (203 mm) from one end of each specimen.

D2.5 Conditioning

Condition specimens at 70°± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum unless otherwise specified. Remove only one specimen at a time from the conditioning environment immediately before being tested.

NOTE: As stated in 14 CFR 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 or soot in the air until the specimen is subjected to the flame.

D2.6 Procedure

D2.6.1 Burner Adjustment

D2.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

D2.6.1.2 Open the stopcock in the gas line fully and light the burner.

D2.6.1.3 Adjust the burner flame to obtain a flame profile so that the outer cone of the flame is 3 inches (76 mm) in length and the inner cone is approximately 1 inch (25 mm) in length. The proper flame length will be obtained by adjusting the needle valve on the burner controlling the gas flow rate.

D2.6.1.4 Burner Placement

For the test, place the burner into position so that the top end of the burner barrel is 1 inch from the mark on the specimen, and the centerline of the burner barrel is perpendicular to the specimen and intersects the specimen at the mark (see figure D2-1).

D2.6.1.5 Alternative Burner Placement

Place the burner into position so that the top end of the burner barrel is 1 inch from the mark on the specimen. Make sure the centerline of the burner barrel is perpendicular to the underside of the mark on the specimen, that the centerline of the burner barrel forms an angle of 30 degrees with the line that is in the vertical plane containing both ends of the specimen, is perpendicular to the specimen, and passes through the mark on the specimen. It has been found convenient to fabricate a fixture to position and hold the location of the burner quickly and repeatedly (see figure D2-3).

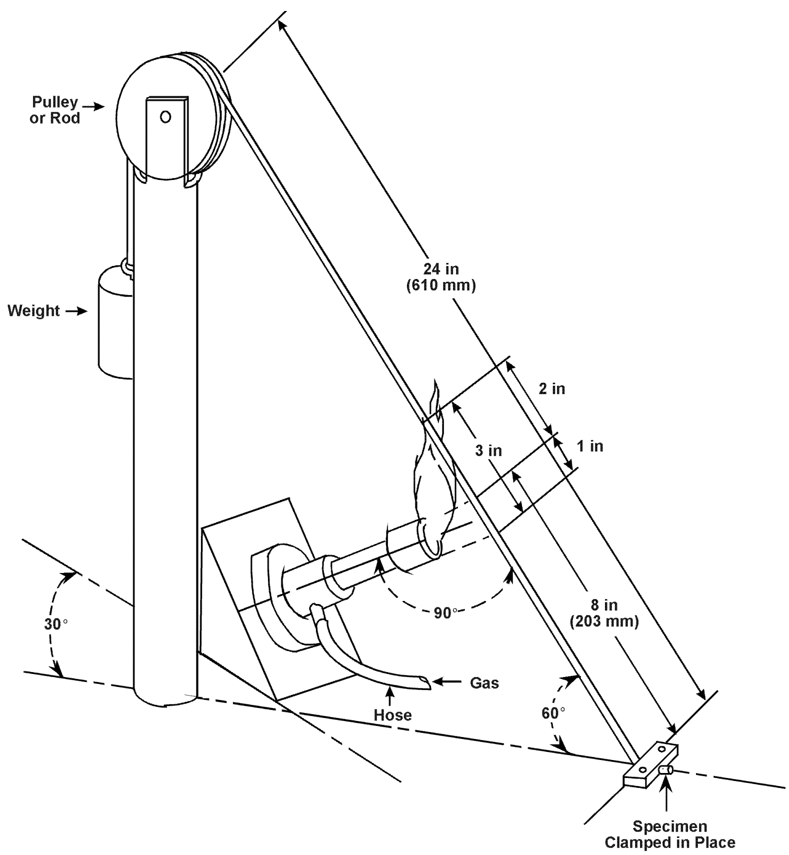


Figure D2-3. Alternative setup for 60-degree electrical wire Bunsen burner test

NOTE: The alternative burner placement conforms to the 30-second, 60-degree Bunsen burner test described in 14 CFR 25, appendix F, Part I through Amendment 25-72. The FAA William J. Hughes Technical Center has determined that the burner placement in section D2.6.1.5 produces equivalent test results.

D2.6.2 Test Procedure

D2.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.

D2.6.2.2 The timer must be started immediately on positioning the burner. Position the burner as described in section D2.6.1.4 so that the tip of the inner cone of the burner flame contacts the gauge mark on the wire.

D2.6.2.3 Apply the flame for 30 seconds, and then withdraw it.

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

D2.6.2.4 If flaming material falls from the test specimen, note the drip flame time for the specimen (see section D2.2.3).

D2.6.2.5 Determine the flame time for the specimen (see section D2.2.2).

D2.6.2.6 After all flaming ceases, remove the specimen and determine the burn length (see section D2.2.4). A dry, soft cloth or tissue, or a soft cloth or tissue dampened with a moderate solvent that does not dissolve or attack the specimen material, such as alcohol, may be used to remove soot and stain particles from tested specimens to facilitate determining the burn length.

NOTE: The operator should refer to the facility's safety manual for further information dealing with smoke and flammability byproducts.

D2.6.2.7 Remove any material that fell from the specimen from the bottom of the cabinet.

D2.7 Report

D2.7.1 Material Identification

Fully identify the wire tested.

D2.7.2 Test Results

D2.7.2.1 Report the flame time for each specimen tested. Determine and record the average value for flame time.

D2.7.2.2 Report the drip flame time for each specimen tested. Determine and record the average value for drip flame time. For specimens that have no drips, record “0” for the drip flame time, and also record “No Drips.”

D2.7.2.3 Report the burn length for each specimen tested. Determine and record the average value for burn length.

D2.8 Requirements

D2.8.1 Extinguishing Time

The average extinguishing time for all the specimens tested will not exceed 30 seconds.

D2.8.2 Drip Extinguishing Time

The average drip extinguishing time for all the specimens tested will not exceed 3 seconds.

D2.8.3 Burn length

The average burn length for all the specimens tested will not exceed 3 inches (76 mm).

D2.8.4 Wire Breakage

It will not be considered a failure if the wire breaks during the test.

Chapter D3
Heat Release Rate Test for Cabin Materials

D3.1 Scope

D3.1.1 Applicability

This test is intended for use in determining heat release rates to show compliance with the requirements of 14 CFR 25.853 at amendment 25-138 and earlier.

D3.1.2 Heat Release Rate

Heat release rate is measured for the duration of the test from the moment the specimen is injected into the controlled exposure chamber and encompasses the period of ignition and progressive flame involvement of the surface.

D3.2 Definitions

D3.2.1 Heat Release

Heat release is a measure of the amount of heat energy evolved by a material when burned. It is expressed in terms of energy per unit area (kilowatt minutes per square meter, kW min/m^2).

D3.2.2 Heat Release Rate

Heat release rate is a measure of the rate at which heat energy is evolved by a material when burned. It is expressed in terms of power per unit area (kilowatts per square meter, kW/m^2). The maximum heat release rate occurs when the material is burning most intensely.

D3.2.3 Heat Flux

Heat-flux density is the intensity of the thermal environment to which a sample is exposed when burned. In this test, the heat-flux density used is 3.5 W/cm^2.

D3.3 Test Apparatus

D3.3.1 Release Rate Apparatus

The apparatus shown in figures D3-1a and D3-1b will be used to determine heat release rates. All exterior surfaces of the apparatus, except the holding chamber, will be insulated with 1-inch-thick (25-mm), low-density, high-temperature, fiberglass board insulation. A gasketed door through which the sample injection rod slides will be provided to form an airtight closure on the specimen holding chamber.

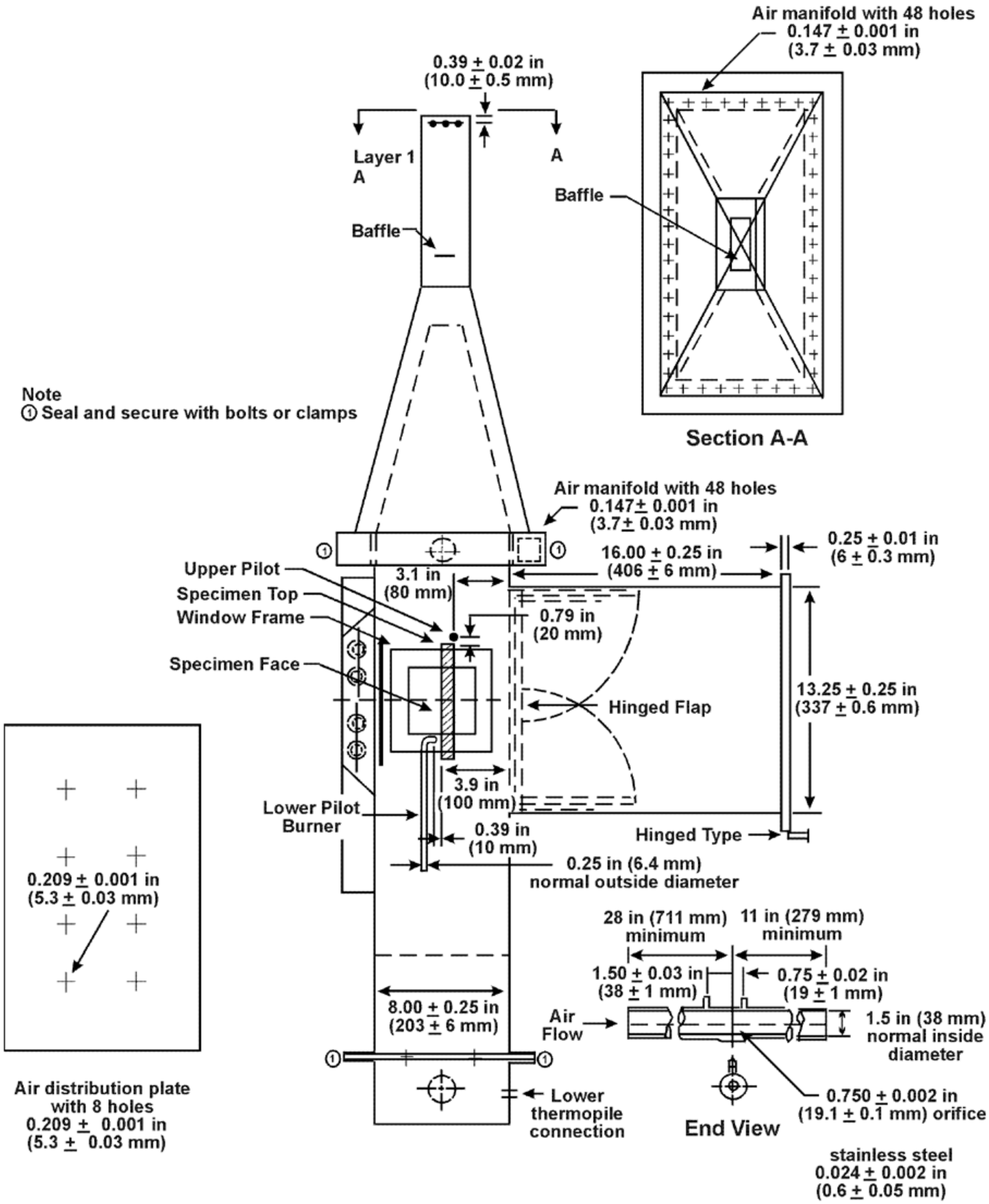


Figure D3-1a. Rate of heat-release apparatus

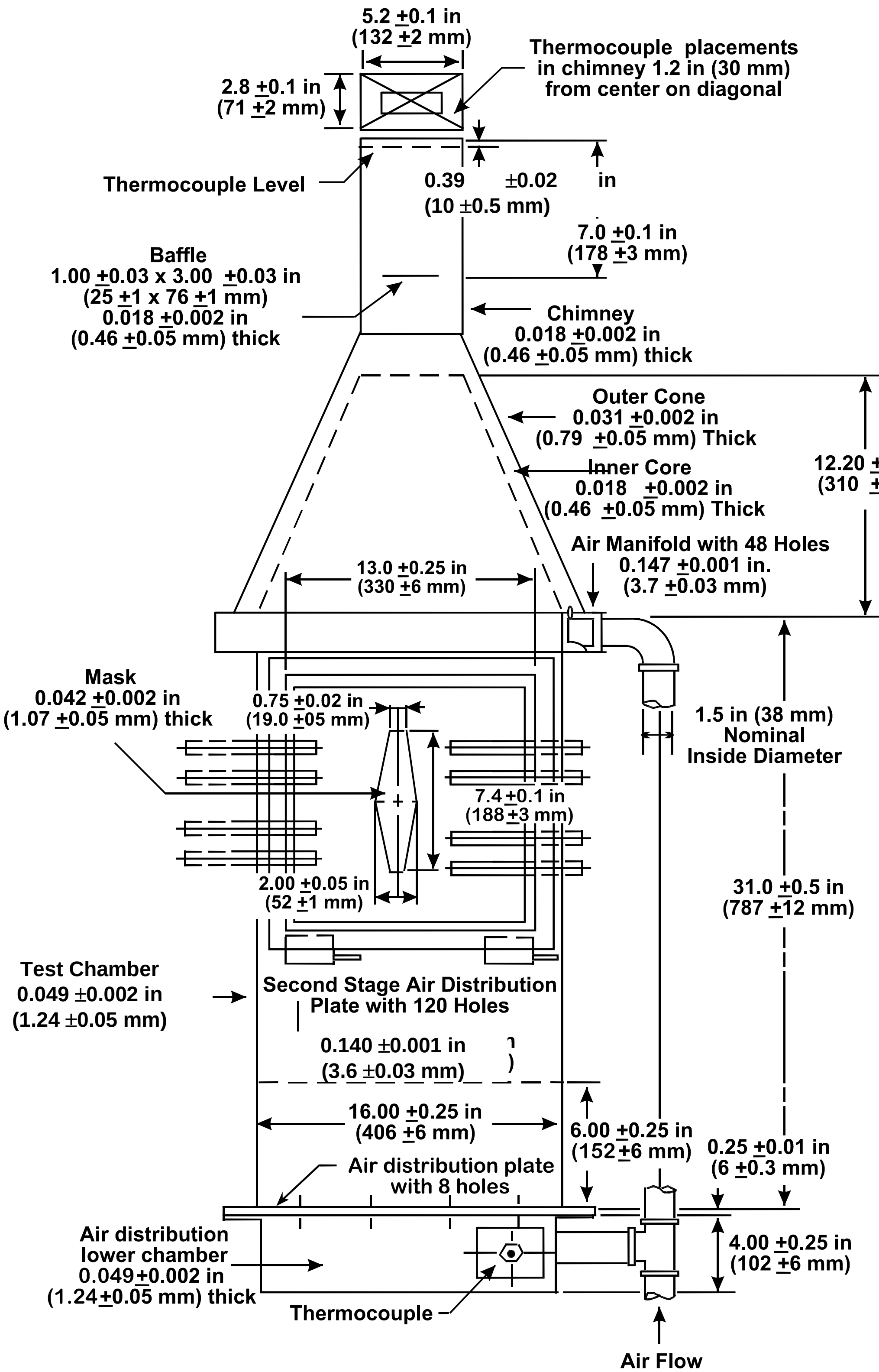


Figure D3-1b. Rate of heat-release apparatus

D3.3.2 Thermopile

The temperature difference between the air entering and leaving the environmental chamber will be monitored by a thermopile having five hot and five cold 24-gauge chromel-alumel junctions (see figure D3-2). The bead to be formed by the thermocouple junction will be 0.050 ± 0.010 inch (1.3 ± 0.3 mm) in diameter. Each junction will be free of insulation for a minimum of 0.75 inch (19 mm). The cold junctions will be located in the pan below the air-distribution plate (see section D3.3.4). The hot junctions will be located 0.38 inch (10 mm) below the top of the chimney. One of the hot junctions will be placed at the center of the chimney's cross section, and the other four will be placed on the chimney diagonals 1.18 inches (30 mm) from the center thermocouple.

NOTE: The upper thermocouples in the thermopile must remain in the same position as when the last calibration was completed. A template may be necessary to maintain this position. Caution must be taken while cleaning the thermocouple junctions not to move them.

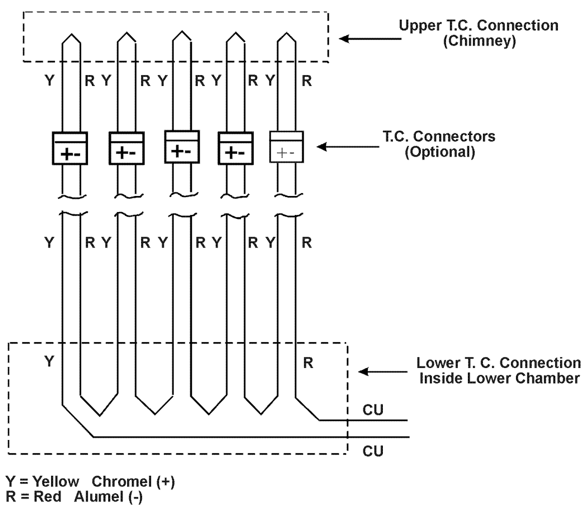


Figure D3-2. Thermopile

D3.3.3 Radiant Heat Source

Use a radiant heat source for generating a flux up to 10 W/cm^2, using four silicon carbide elements Type LL, 20 inches (508 mm) by 0.63 inch (16 mm), nominal resistance 1.4 ohms, as shown in figures D3-1a, D3-1b, and D3-3. The silicon carbide elements will be mounted in the stainless-steel panel box by inserting them through 0.63-inch (16-mm) holes in ceramic insulating devices or calcium-silicate millboard. Locations of the holes in the pads and stainless-steel covered plates will be as shown in figure D3-3. A truncated, diamond-shaped mask, constructed of 0.042 ± 0.002-inch (1.07 ± 0.05 mm) stainless steel, will be added to provide uniform heat-flux density over the area occupied by the 5.94- by 5.94-inch (151- by 151-mm) vertical sample. An adjustable power supply capable of producing 12.5 kVA will be provided. The heat flux over the specimen surface when set at 3.5 W/cm^2 will be uniform within 5 percent and will be checked periodically and after each heating element change. Uniformity of heat-flux density will be determined by heat-flux sensor measurements at the center and at the four corners of the specimen surface.

NOTE: A device should be provided to monitor the current of the heating elements (globars) during testing; additionally, this may be used to adjust the globar current during initial warmup, before final adjustment.

D3.3.4 Air-Distribution System

The air entering the apparatus will be 70°F–75°F (21°C–24°C) and set at approximately 85 ft^3/min (0.04 m^3/s) using an orifice meter. The orifice meter will be comprised of a squared-edged, circular-plate orifice, 0.024 inches thick (0.5 mm), located in a circular pipe with a nominal diameter of 1.5 inches (38 mm), with two pressure measuring points located 1.5 inches (38 mm) upstream (above) and 0.75 inches (19 mm) downstream (below) of the orifice and connected to a mercury manometer. The inlet pipe will remain a nominal diameter of 1.5 inches (38 mm) (see figure D3-la).

NOTE: The inner edges of the holes must be sharp. The holes in the lower plate are #4 drill size. The holes in the upper manifold are #26 drill size. The holes in the intermediate plate used for airflow disbursement are #28 drill size.

D3.3.4.1 The air entering the environmental chamber will be distributed by a 0.25-inch (6.3-mm) thick aluminum plate having eight 0.209 ± 0.001-inch (5.3 ± 0.03-mm) diameter holes, 2 inches (51 mm) from the sides on 4-inch (102-mm) centers, mounted at the base of the environmental chamber. A second plate having 120 evenly spaced, 0.140 ± 0.001-inch (3.6 ± 0.03-mm) diameter holes will be mounted 6 inches (152 mm) above the aluminum plate (see figure D3-1b).

D3.3.4.2 The air-supply manifold at the base of the pyramidal section will have 48 evenly spaced, 0.147 ± 0.001-inch (3.7 ± 0.03-mm) diameter holes, 0.38 inch (10 mm) from the inner edge of the manifold, resulting in an airflow split of approximately 3:1 within the apparatus (see figure D3-1a).

D3.3.5 Exhaust Stack

An exhaust stack, 5.25 by 2.75 inches (133- by 70 mm) in cross section and 10 inches (254 mm) long, fabricated from stainless steel, 0.018 ± 0.002 inch (0.46 ± 0.05 mm), will be mounted on the outlet of the pyramidal section (see figures D3-1a and D3-1b). A 1- by 3-inch (25 by 76-mm) plate of 0.018 ± 0.002-inch thick (0.46 ± 0.05-mm) stainless steel will be centered inside the stack, perpendicular to the airflow, 3 inches (76 mm) above the base of the stack.

NOTE: The exhaust stack and area above the upper manifold should be cleaned periodically of soot deposits.

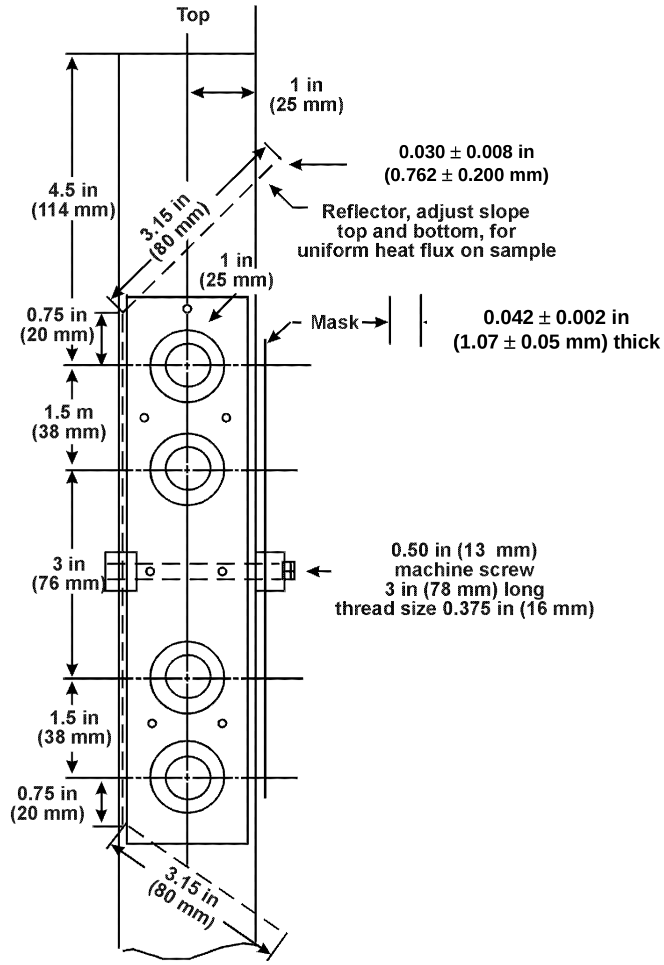


Figure D3-3. Side view—Globar radiant heat panel

D3.3.6 Specimen Holders

Specimen holders will be fabricated from a stainless-steel sheet, 0.018 ± 0.002 inch (0.46 ± 0.05 mm) thick, as shown in figure D3-4. Specimen holders will be attached to the injection rod using the mounting bracket shown in figure D3-4. Each holder will be provided with a V-shaped spring pressure plate. The position of the spring pressure plate can be changed to accommodate different specimen thicknesses by inserting the retaining rod in different holes of the specimen holder frame. Each holder will also have two wires attached vertically to the front of the holder to secure the face of the specimen in the holder.

D3.3.6.1 Drip Pan

A drip pan will be fabricated from a stainless-steel sheet, 0.018 ± 0.002 inch (0.46 ± 0.05 mm) thick, and be attached to the specimen holder using the flanges shown in figure D3-4. Drip pans may be needed to prevent melting specimens from dripping into the lower test section. Foil can be used to line the drip pan to facilitate cleaning after use.

D3.3.7 Heat-Flux Sensor

A water-cooled, foil-type Gardon gauge heat-flux sensor will be used to measure the heat-flux density at a point where the center of the specimen surface is located at the start of the test. When positioned to measure heat-flux density, the sensor surface will be flush with the supporting device surface so that air heated by such a support does not contact the sensor surface.

NOTE: A second calorimeter should be used periodically to check the active calorimeter, and its calibration should be first generation from NIST or the calorimeter manufacturer.

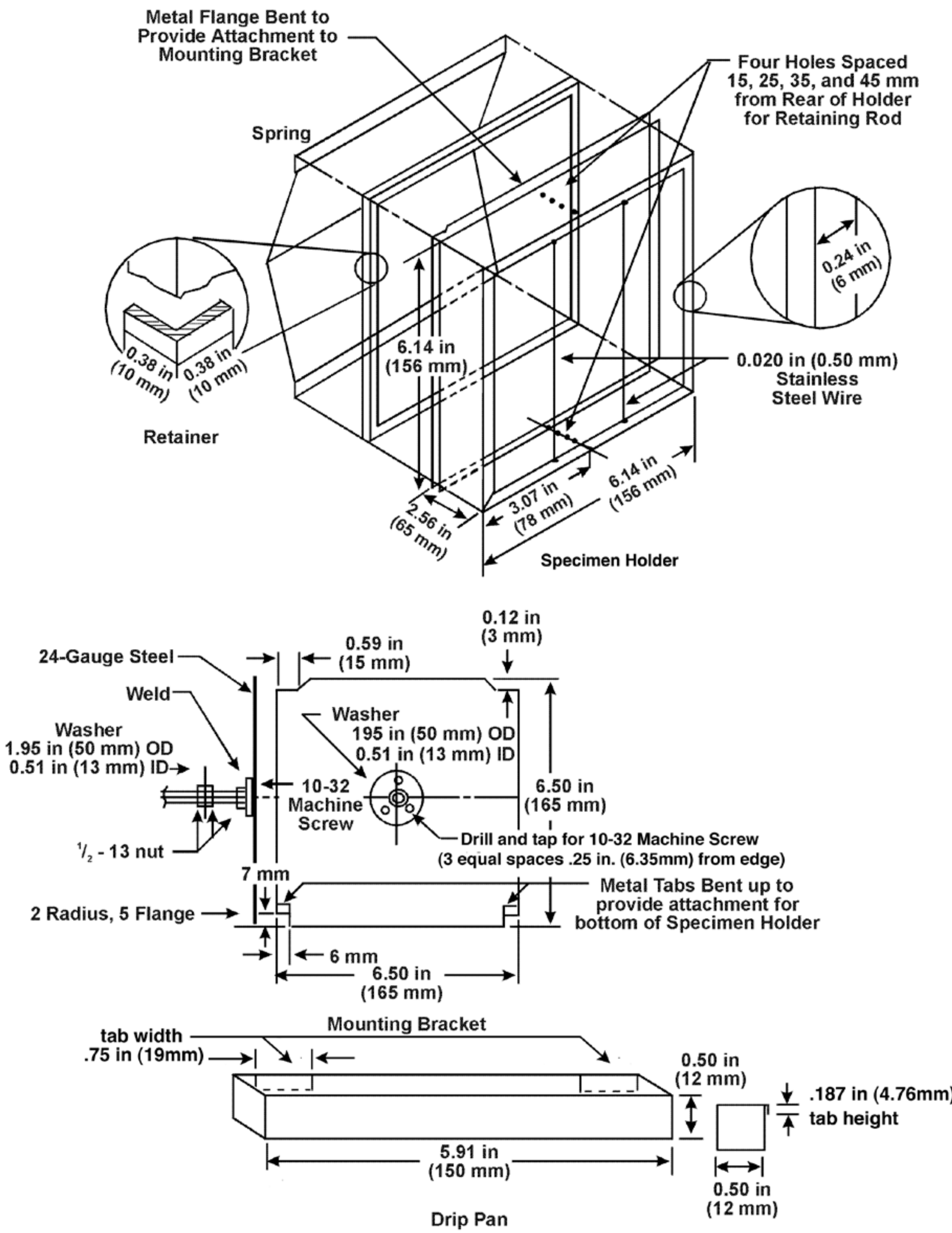


Figure D3-4. Heat-release specimen holder, mounting bracket, and drip pan

D3.3.8 Pilot Burners

Pilot burners will be placed at locations near the bottom and top of the specimens (see figure D3-1a). The burners will be constructed of stainless-steel tubing with a 0.25-inch (6.4-mm) outside diameter (OD) and a 0.03-inch (0.8-mm) wall thickness.

D3.3.8.1 Lower Pilot Burner

The lower pilot burner will be located as shown in figure D3-1a. The lower pilot burner will have its centerline perpendicular to the surface of the specimen and 0.19 inch (5 mm) above the specimen's lower exposed edge and will have its end 0.38 inches (10 mm) from the specimen surface. A methane/air mixture will be used, consisting of 0.004 ft^3/min (120 cm^3/min) (at standard temperature and pressure [STP]) methane (99 percent minimum purity) and an air supply adjusted to produce a flame such that the inner cone is approximately the same length as the diameter of the burner tube (see figure D3-5).

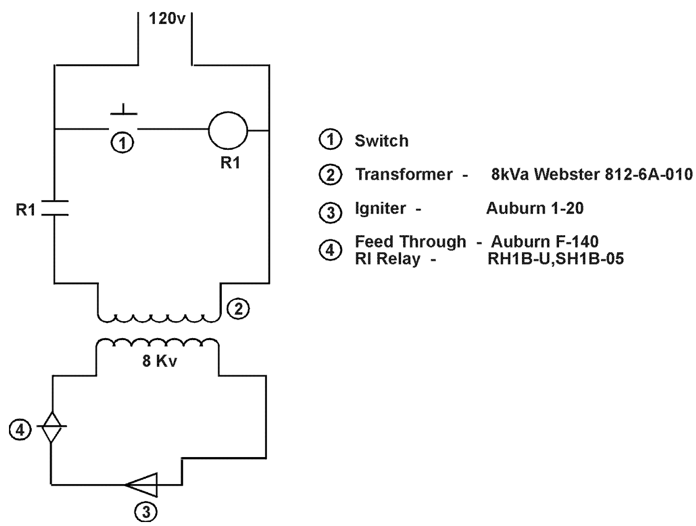


Figure D3-5. Lower pilot burner igniter schematic

D3.3.8.2 Upper Pilot Burner

An upper pilot burner will be provided to produce 15 flamelets above the test specimen to ignite flammable gases (see figure D3-6). During the test, if there is any period of time longer than three seconds when any three or more of the flamelets on the upper pilot burner are not burning, the test is invalidated.

NOTE: The upper pilot holes are #59 drill size.

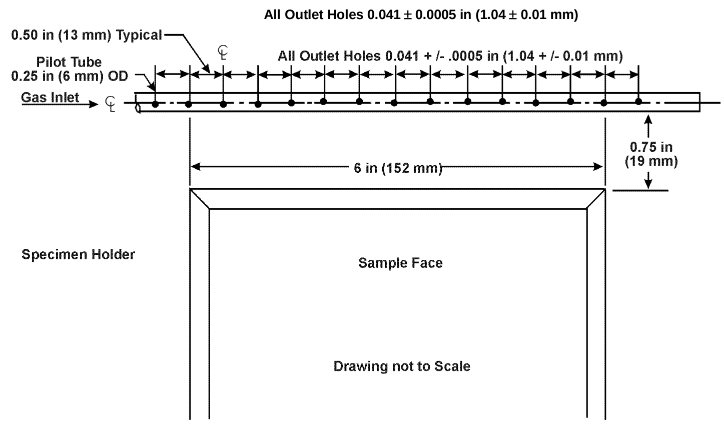


Figure D3-6. Upper pilot burner—15-hole burner

D3.3.8.2.1 The upper pilot burner will be constructed from a piece of stainless-steel tubing with an outside diameter of 0.25 inch (6.3 mm) and a wall thickness of 0.03 inch (0.8 mm). Fifteen 0.041 ± 0.0005-inch (1.04 ± 0.01-mm) diameter holes, each radiating in the same direction, will be drilled into a 15-inch (381-mm) length of tubing. The holes will be spaced 0.5 inch (13 mm) apart with the first hole located 0.5 inch (13 mm) from the closed end, as shown in figure D3-6. The tubing will be inserted into the environmental chamber through a 0.25-inch (6.3-mm) hole drilled to locate the tubing 0.79 inch (20 mm) above and 0.79 inch (20 mm) behind the upper-front edge of the specimen holder and installed so that the holes are directed horizontally toward the radiant heat source. One end of the tubing will be closed with a silver solder plug or equivalent.

D3.3.8.2.2 The burner will be positioned above the specimen holder so that the holes are placed above the specimen holder facing the heat source, as shown in figure D3-1a.

D3.3.8.2.3 The fuel fed to this burner will be methane of 99 percent minimum purity mixed with air in a ratio of approximately 50/50 by volume. The total fuel flow will be adjusted to provide flamelets approximately 1 inch (25 mm) long. When the gas/air ratio and its fuel flow rate are properly adjusted, approximately 0.25 inch (6 mm) of the flame length will appear yellow.

D3.4 Test Specimens

D3.4.1 Specimen Size

The standard size for specimens is 5.94 + 0, -0.06 by 5.94 + 0, -0.06 inches (150 + 0, -2 by 150 + 0, -2 mm) in lateral dimensions. Specimen thickness is as used in the relevant application up to 1.75 inches (45 mm); applications requiring thicknesses greater than 1.75 inches (45 mm) will be tested in 1.75-inch (45-mm) thicknesses.

D3.4.2 Specimen Number

A minimum of three specimens will be prepared and tested for each material/part.

NOTE: For test purposes, specimens should be marked with an arrow by manufacturers or operators for a consistent direction.

D3.4.3 Specimen Mounting

Only one surface of a specimen will be exposed during a test. A single layer of 0.0012 ± 0.0005-inch-thick (0.03 ± 0.01-mm) aluminum foil will be wrapped tightly on all unexposed sides with the dull side of the foil facing the specimen surface. The foil must be continuous and not torn. The retaining frame will be placed behind the specimen between the back of the specimen and the pressure plate.

D3.4.4 Specimen Orientation

For materials that may have anisotropic properties (i.e., different properties in different directions, such as machine and cross-machine directions for extrusions, warp, and fill directions of woven fabrics), the specimens will be tested in the orientation thought to give the highest results. If the average maximum heat-release rate exceeds 58 kW/m^2 or the average total heat released during the first 2 minutes exceeds 58 kW min/m^2, a second set of specimens will be prepared and tested in the orientation that is perpendicular to the orientation used for the first set of specimens. The higher value for the average maximum heat release rate and the higher value for the average total heat released during the first 2 minutes will be reported.

NOTE: If there is evidence that a material does not demonstrate isotropic flammability characteristics and its heat release numbers in any one direction average greater than 58, either 2 minute or peak, the material must be tested in both directions. Examples of those types of materials that may not exhibit isotropic flammability characteristics are rugs and textiles.

D3.5 Conditioning

D3.5.1 Specimens will be conditioned at 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for a minimum of 24 hours prior to test.

D3.6 Calibration

D3.6.1 Calibration Burner

A calibration burner, as shown in figure D3-7, will be provided that fits over the end of the pilot flame tubing with a gas-tight connection. T-bar outlets will be approximately the same height as the lower pilot outlet.

NOTE: The calibration T-bar burner holes are #32 drill size.

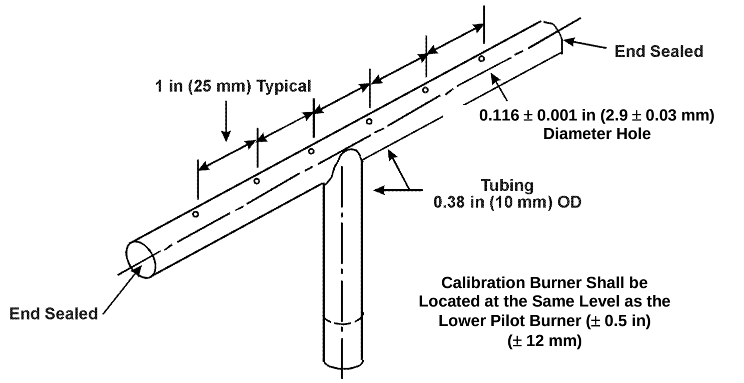


Figure D3-7. Typical calibration burner

D3.6.2 Calibration Gas

Methane of at least 99 percent purity will be used for calibration purposes.

D3.6.3 Wet Test Meter

A wet test meter accurate to 0.007 ft^3/min (0.2 L/min) will be provided to measure the gas flow rate to the calibration burner. Prior to usage, the wet test meter will be leveled and filled with distilled water to the tip of the internal pointer, according to manufacturer instructions.

NOTE: The tubing from the wet test meter to the calibration T-bar must be as short as possible and direct in routing. Also, the wet test meter must be last in line to the calibration T-bar.

D3.6.4 Calibration Gas Manifold

D3.6.4.1 A means will be provided upstream of the wet test meter to control calibration gas flow. The means will have flow orifices preset to provide calibration gas at approximate (uncorrected for the presence of water vapor) flow rates of 0.035 ft^3/min, 0.14 ft^3/min, 0.21 ft^3/min, and 0.28 ft^3/min (1 L/min, 4 L/min, 6 L/min, and 8 L/min), as indicated by revolution rate (measured by a stop watch accurate to 1 second) of the wet test meter. Output from each of the flow orifices will be controlled by an on/off means and be plumbed into a single-flow line so that the calibration gas flow rate to the calibration burner can be set at 0.035 ft^3/min, 0.14 ft^3/min, 0.21 ft^3/min, or 0.28 ft^3/min (1 L/min, 4 L/min, 6 L/min, and 8 L/min).

D3.6.4.2 The actual, corrected value, F, of each of the flow rates will be determined to an accuracy of 0.007 ft^3/min (0.2 L/min), and these corrected values are used for calibration calculations in section D3.6.6.

D3.6.5 Calibration Procedure

D3.6.5.1 Replace the lower pilot burner with the calibration burner shown in figure D3-7.

D3.6.5.2 Install the wet test meter. Ensure that it is level and filled with distilled water. Ambient temperature and water pressure are based on the internal wet test meter temperature.

D3.6.5.3 Turn on the air-distribution system.

D3.6.5.4 Turn on the radiant heat source and ensure that the heat flux is 3.5 ± 0.05 W/cm^2.

D3.6.5.5 Using the calibration gas manifold, set the baseline flow rate of 1 L/min of methane to the calibration burner and light the burner. Measure the thermopile baseline voltage.

D3.6.5.6 Immediately prior to recording the thermopile outputs, as discussed in section D3.6.5.7, precondition the chamber at a methane flow rate of 8 L/min for 2 minutes. Do not record the thermopile output for this step as part of the calibration.

D3.6.5.7 The gas flow to the burner is increased to a higher flow rate and then decreased to the baseline flow rate. After 2 minutes of burning at each rate, monitor the thermopile output (millivolts) for a 10-second period, record the average reading, and decrease the flow rate to the baseline flow of 1 L/min. This sequence of increasing and decreasing the methane flow rate is as follows: 0.035–0.14 ft^3/min; 0.035–0.21 ft^3/min; 0.035–0.28 ft^3/min; 0.035–0.21 ft^3/min; 0.035–0.14 ft^3/min (1–4 L/min; 1–6 L/min; 1–8 L/min; 1–6 L/min; 1–4 L/min).

D3.6.6 Compute the calibration factor for each upward rate step (i.e., 1–4 L/min; 1–6 L/min; 1–8 L/min; 1–6 L/min; 1–4 L/min) according to the following formula:

$$k_h = 25.31 \times \frac{273}{T_a} \times \frac{(P_a - P_v)}{760} \times \frac{(F_1 - F_0)}{(V_1 - V_0)} kW/m^2 - mv$$

where:

F_1 = Actual upper flow rate of calibration gas, in L/min (either 4, 6, or 8)
F_0 = Actual baseline flow rate of methane, in L/min (approximately 1 L/min)
P_a = Ambient atmospheric pressure, in mm Hg
P_v = Water vapor pressure of wet test meter water temperature, in mm Hg
T_a = Ambient temperature, in °K
V_1 = Thermopile voltage at upper flow rate, in *mv*
V_0 = Thermopile voltage at baseline flow rate, in *mv*

D3.6.7 Average the five results and compute the percent relative standard deviation. If the percent relative standard deviation is greater than 5 percent, repeat the determination. If it is less than 5 percent, use the average as the calibration factor.

D3.7 Test Procedure

D3.7.1 Set the airflow to the equipment by adjusting the pressure differential across the orifice plate to 7.87 inches (200 mm) of mercury.

D3.7.2 Set the power supply to the globars to produce a radiant flux density of 3.5 ± 0.05 W/cm^2 at the point that the center of the front surface of the specimen will occupy when positioned for the test.

D3.7.3 Light the pilot flames and check that their positions are as described in sections D3.3.8.1 and D3.3.8.2. Activate the spark igniter if one is used.

D3.7.4 If the test specimen consists of material that sags or drips to the extent that part of it may fall out of the holder during the test, attach the drip pan to the specimen holder, as described in section D3.3.6.1.

D3.7.5 Place the specimen in the hold chamber with the radiation shield doors closed. Secure the airtight outer door, and start the recording devices. Hold the specimen in the hold chamber for 60 ± 10 seconds.

D3.7.6 Record, at least once per second, the thermopile millivolt output during the final 20 seconds of the hold time before the specimen is injected; report the average as the baseline thermopile reading (millivolts).

NOTE: Extreme caution must be used to ensure that the baseline reading is completed prior to opening inner doors for sample injection.

D3.7.7 After recording the baseline reading and within a timeframe not exceeding 3 seconds, open the radiation doors, inject the specimen into the burn chamber, and close the radiation doors. Record thermopile millivolt outputs at least once a second for the duration of the test.

D3.7.8 After the test has run for 5 minutes, terminate the test, and remove the sample.

D3.7.9 Observe and note any extinguishment of pilot flames, then discard data from any test during which the lower pilot burner was extinguished for any period of time exceeding 3 seconds or during which at least 3 of the upper pilot flamelets were extinguished simultaneously for any period of time exceeding 3 seconds.

NOTE: The use of an externally positioned mirror may assist in viewing upper pilot flames during testing.

D3.7.10 Calculate the heat release rate for any point of time from the reading of the thermopile output voltage, V, at that time as heat release rate = $k_h \times (V_1 - V_0)$, where k_h and V_0 are the calibration factor and thermopile millivolt reading at the baseline, respectively.

D3.7.11 Determine and record the maximum heat release rate during the 5-minute test.

D3.7.12 Compute and record the total heat released during the first 2 minutes of testing by integrating the heat release rate versus time curve during the first 2 minutes.

D3.7.13 Clean the thermopile hot junctions to remove soot after testing each set of specimens.

NOTE: A small, soft-bristled brush has been found satisfactory. Do not disturb the position of the thermocouples. Ensure that the thermocouples are in their proper positions before proceeding with the next specimen; a template may be used to facilitate this step.

D3.8 Report

D3.8.1 Fully identify the material tested, including thickness.

D3.8.2 Determine and record the average maximum heat release rate during the 5-minute test and the average total heat released during the first 2 minutes for all specimens tested (in worst-case direction).

D3.8.3 Report the radiant heat flux to the specimen in W/cm^2 and data giving release rates of heat (in kW/m^2) as a function of time, either graphically or tabulated at intervals no greater than 10 seconds, and the calibration factor k_h.

D3.8.4 Report any melting, sagging, delamination, or other behavior that affected the exposed surface area or mode of burning that occurred, and the time(s) at which such behavior occurred.

D3.9 Requirements

D3.9.1 The average maximum heat release rate during the 5-minute tests will not exceed 65 kW/m^2.

D3.9.2 The average total heat released during the first 2 minutes will not exceed 65 kW min/m^2.

NOTE: The 65/65 acceptance criteria above are the definitive requirements in CFR 25, Amendment 25-61 (14 CFR 25.853[a-1]), covering affected new design airplanes whose Type Certificate was applied for after August 20, 1986. These definitive requirements are referenced in CFR 121, Amendment 121-189, and are required for all affected airplanes manufactured after August 20, 1990. All affected airplanes manufactured after August 20, 1988, but prior to August 20, 1990, must meet interim requirements of 100 kW/m^2 for the average heat release rate and 100 kW min/m^2 for the average total heat released during the first 2 minutes.

Chapter D3 Supplement

This supplement contains advisory material pertinent to the referenced paragraphs.

D3.3.8 Upper Pilot Burner Hot Surface Igniter

It is critical that the upper pilot burner tube is not moved out of position once set correctly. If the tube is inadvertently moved forward (toward the globars), there is a chance that a large portion of the upper pilot flames will go out entirely in the presence of fire retardants, whereas, when in the correct position, only the flame tiplets will be impacted while the material is burning off. The difference between the two conditions could have a dramatic effect on the data.

In the event a material continues to impact the upper pilot flames even with the burner tube in the correct position, an optional HSI may be installed. Alternatively, the HSI may be installed and used for all materials tested. If the HSI is installed, the center heat flux and 5 percent uniformity requirement (see section D3.6) must be verified subsequent to a methane gas calibration.

A 0.125 ± 0.005-inch (3 ± 0.1 mm) diameter ceramic rod 8.0 ± 0.0625 inches (203 ± 1.6 mm) in length is positioned directly in the flames of the upper pilot burner. The rod is continuously heated by the flamelets, acting as a hot surface igniter to auto-ignite any upper pilot flames should they go out (see figures D3-S-1 and D3-S-2). The distance from the centerline of the burner tube to the centerline of the HSI rod is 0.75 ± 0.125 inch (19 ± 3 mm).

NOTE: Non-Porous High-Alumina Ceramic Rod (McMaster-Carr P/N 87065K42) has been found acceptable.

Two stainless-steel support brackets are mounted on the upper pilot burner tube. The brackets are separated 8.0 ± 0.0625 inches (203 ± 1.6 mm) from each other (outer dimension) with one bracket aligned flush with the closed end of the burner tube (see figures D3-S-3 and D3-S-4). Because of forced airflow through the chamber and convection, the upper pilot flames tend to curve upward. To locate the HSI rod in the hottest portion of the burner flames, the brackets are rotated upward 15 ± 5 degrees on each end (setting the bottom of the brackets level will achieve the correct angle). It is not necessary for each bracket to be at the same angle if the rod is in the direct flame path across its entire length (see figure D3-S-2). Set screws secure the brackets in position.

NOTE: Marlin Engineering, Inc. Bracket P/N ME1240-45 has been found acceptable.

The HSI rod must be cleaned or replaced when showing signs of soot buildup or wear. Unless otherwise specified, dimensions are nominal values in inches.

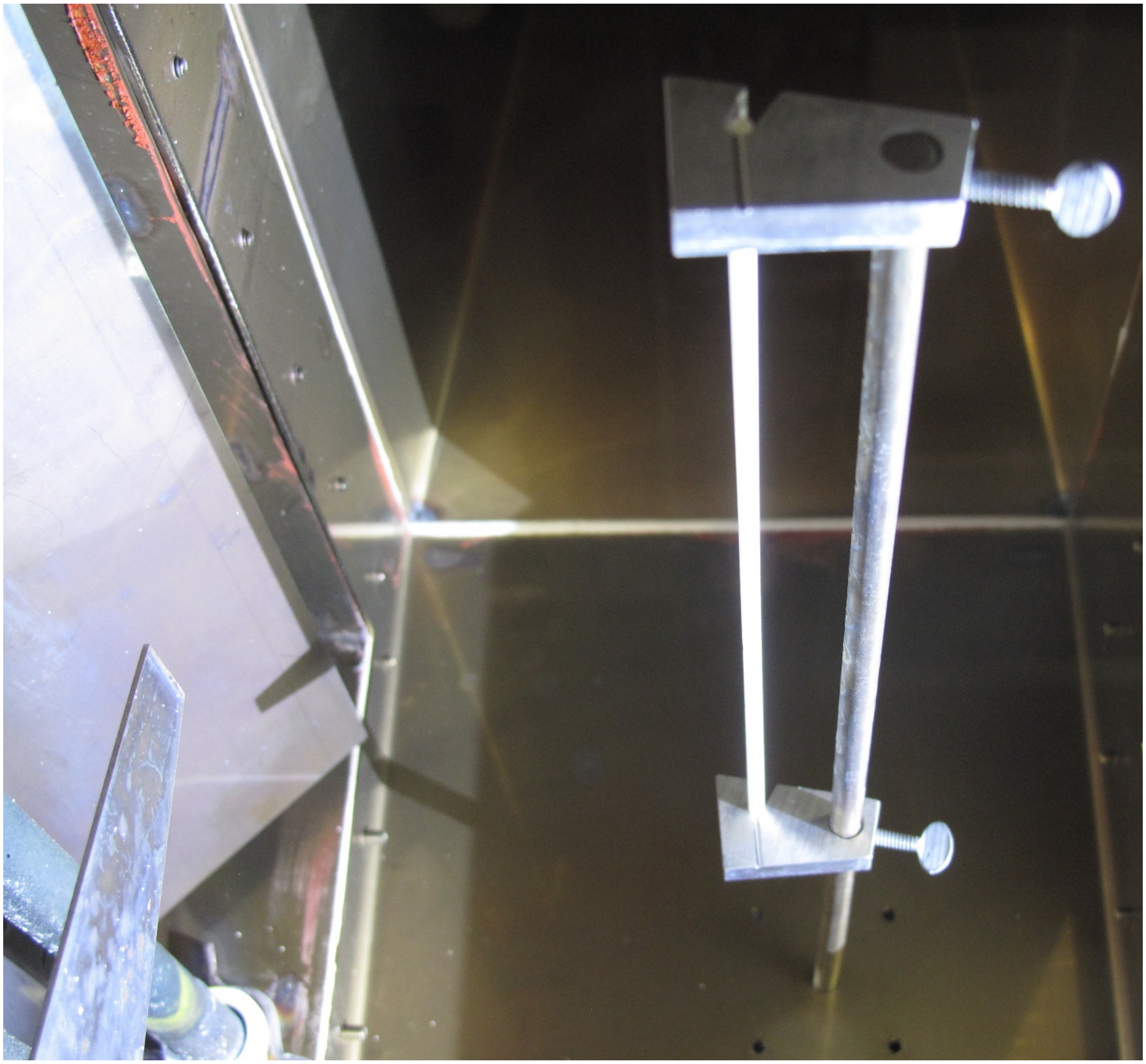


Figure D3-S-1. HSI/Upper pilot burner installation

Figure D3-S-2. HSI/Upper pilot burner operation

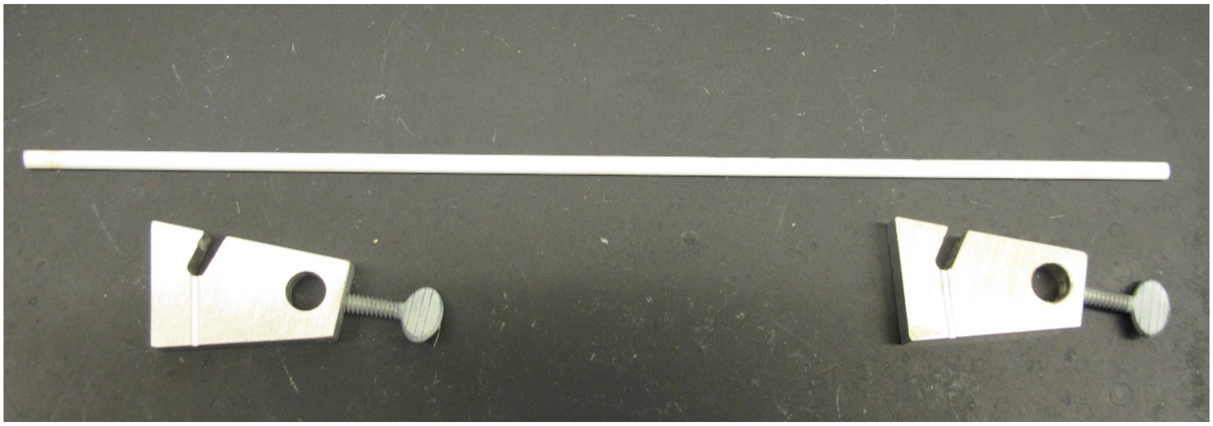


Figure D3-S-3. HSI rod and bracket

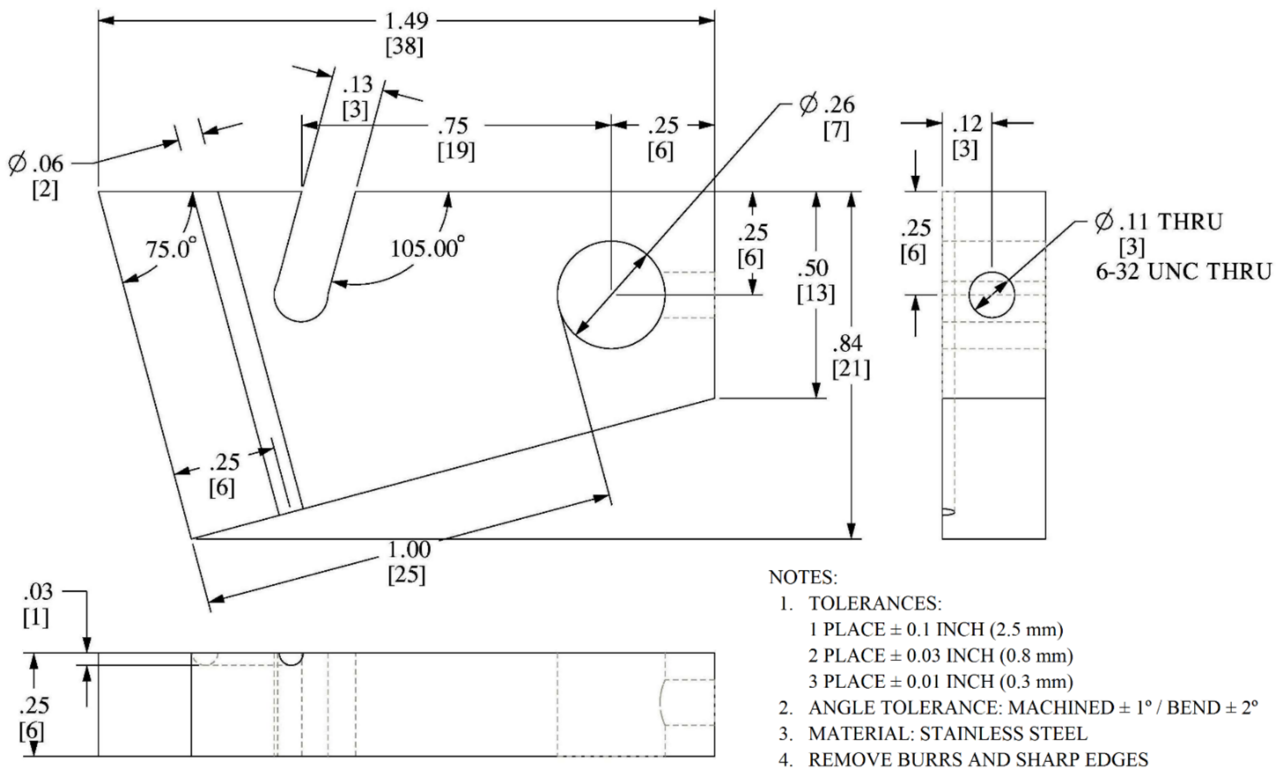


Figure D3-S-4. Upper pilot burner HSI bracket

Chapter D4
Smoke Test for Cabin Materials

D4.1 Scope

D4.1.1 Applicability

This is a test method to determine the smoke-generating characteristics of airplane passenger cabin interior materials to demonstrate compliance with the requirements of 14 CFR 25.853.

D4.2 Definitions

D4.2.1 Specific Optical Density (D_s)-Specific Optical Density

Specific optical density (D_s) is a dimensionless measure of the amount of smoke produced per unit area by a material when it is burned. In this test, the maximum value of D_s that occurs during the first 4 minutes of a test, ${}^4D_m$, is reported.

NOTE: In most cases, the maximum specific optical density (${}^4D_m$) should be at 4 minutes; however, it is possible for the maximum to occur earlier in the test because of coagulation of smoke particles or adsorption of smoke particles to the walls of the chamber.

D4.3 Test Apparatus

D4.3.1 Required Equipment

The test chamber and related equipment (e.g., radiant heat furnace, heat-flux density gauge, specimen holders, photometric system, multidirectional pilot burner) are defined as follows.

D4.3.1.1 Test Chamber

The test chamber will be a square-cornered box with inside dimensions of 36 ± 0.13 inches (914 ± 3 mm) wide, 24 ± 0.13 inches (610 ± 3 mm) deep, and 36 ± 0.13 inches (914 ± 3 mm) high. A typical test chamber is shown in figure D4-1. The location or size of items, such as the chamber door, chamber controls, and flowmeters, is optional, except as mandated in the following sections.

NOTE: Commercially available panels of porcelain-enameled steel (interior surface) permanently laminated to a magnesia insulation core and backed with galvanized steel (exterior surface) have been found acceptable.

A thin sheet of transparent material may be placed over optical and viewing windows to protect them from corrosive components in the smoke.

D4.3.1.1.1 The interior surfaces (except for the chamber door and vents) will be porcelain-enameled metal or equivalent coated metal that is resistant to chemical attack and corrosion, and suitable for periodic cleaning. The chamber will be equipped with a door, such as that indicated in figure D4-1, to provide convenient access for changing test specimens and for cleaning the chamber walls as required. The door will have a viewing window to observe the sample and pilot flamelets' behavior during a test, especially when any of the flamelets extinguish (see section D4.7.2.10).

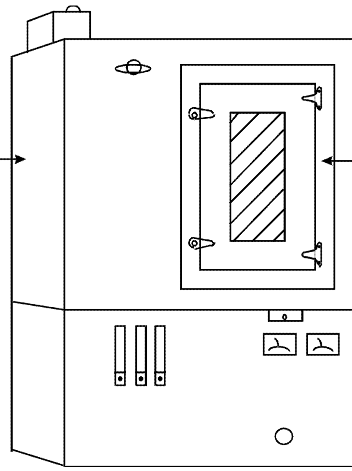


Figure D4-1. Typical smoke-density chamber

D4.3.1.1.2 An inlet-outlet vent for pressure equalization will be provided. The vent and chamber door will have a seal so that when it is closed during tests, there will be no leakage of chamber contents, and a small positive pressure can be developed and maintained inside the test chamber.

D4.3.1.2 Manometer

A device such as a manometer or pressure transducer will be provided to monitor chamber pressure and leakage. The device will have a range of up to 6 inches (152 mm) of water and will be connected to a suitable port in the test chamber.

D4.3.1.3 Pressure Regulator

A pressure regulator will be provided that consists of a water-filled bottle vented to a suitable exhaust system and a piece of tubing, not to exceed 10 feet (305 cm) in length, that has an inside diameter of at least 1 inch (25 mm). One end of the tubing will be connected to a port within 6 inches of the top of the chamber; the other end of the tubing will be held in position 4 inches (102 mm) below the water surface.

NOTE: Venting the water-filled pressure regulator to a suitable exhaust system is necessary to prevent the buildup of unknown contaminants in the laboratory area. The location of the pressure-relief tube should be on or within 6 inches of the top of the chamber.

D4.3.1.4 Test-Chamber Wall Thermocouple

The temperature of the test-chamber wall will be monitored by a thermocouple suitable for measuring a temperature of 35°C. The thermocouple will be mounted with its junction secured to the geometric center of the inner-rear wall panel of the chamber using an electrically insulating disk cover.

D4.3.1.5 Electric Power

A single-phase electric power of 650 W will be provided for the radiant heat furnace and accessories. If line voltage fluctuations exceed 2.5 percent, a constant voltage transformer will be provided.

NOTE: A powerstat variable autotransformer, Type 21, from Superior Electric Co., Bristol, Connecticut, or equivalent has been found satisfactory to transform electric power to that required by the chamber.

NOTE: A constant-voltage transformer from Sola Electric Co., Chicago, Illinois, Catalog Number 23-13-150, or equivalent, has been found satisfactory. A Sorenson Model 200S AC voltage regulator, or equivalent, has been found satisfactory.

D4.3.1.6 Radiant Heat Furnace

An electric furnace and associated controlling devices (see figures D4-2 and D4-3) will be provided that are capable of providing a constant thermal flux density of 2.5 ± 0.05 W/cm^2 (2.2 ± 0.04 Btu/ft^2/sec) on the specimen surface.

NOTE: Furnace model P/N 6806025700 from Newport Scientific has been found acceptable. Furnace model P/N 680860380000 from Newport Scientific has also been found acceptable. A calibration device, P/N 4-5808, is also available from Newport Scientific.

D4.3.1.6.1 Furnace Construction

The dimensions shown in figure D4-2 for the electric furnace are critical. The furnace will be located centrally along the long axis of the chamber, with the opening facing toward and approximately 12 inches (305 mm) from the right wall. The centerline of the furnace will be approximately 7.75 inches (197 mm) above the chamber floor.

D4.3.1.6.2 Heating Element

The heating element will consist of a coiled wire capable of dissipating about 525 W. With the furnace installed, the heating element will be positioned so that the coil loops are at the 12 o'clock position, as shown in figure D4-3.

D4.3.1.6.3 Furnace Control System

The furnace control system will be capable of controlling the radiant heat output at the required level of 2.5 ± 0.05 W/cm^2 (2.2 ± 0.04 Btu/ft^2/sec), as measured by the heat-flux density gauge, under steady-state conditions with the chamber door closed for at least 5 minutes. The control system will consist of an AC solid-state voltage or power controller and a voltmeter, or other means for monitoring the electrical input.

NOTE: A model 470 Series power controller manufactured by Eurotherm and a Model 3AEV1B10C1 Triac manufactured by GE®, or equivalent, have been found satisfactory. The furnace control system should be a reputable unit that provides the parameters to fulfill the requirements of the furnace.

It is recommended to use a digital voltmeter to monitor the furnace voltage output and a digital amperemeter to monitor the furnace current.

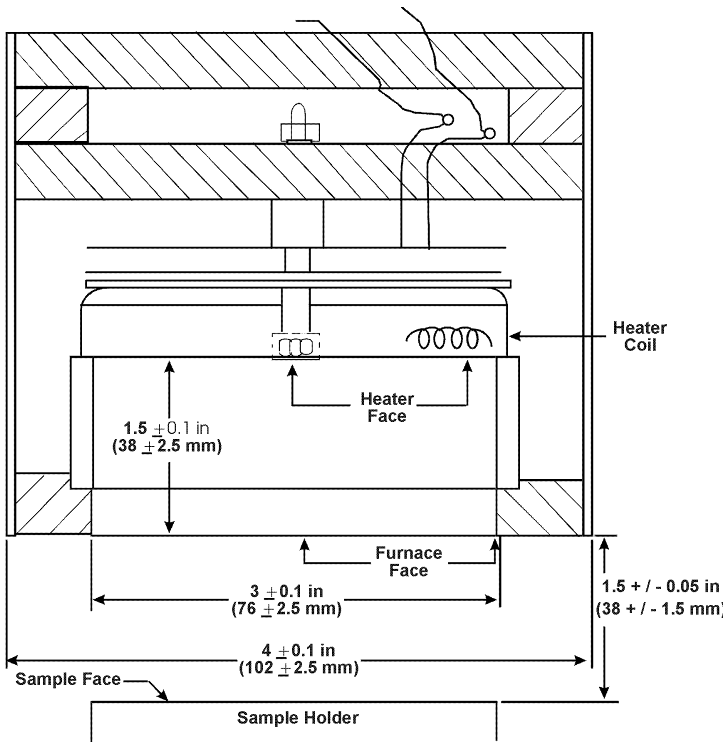


Figure D4-2. Furnace section

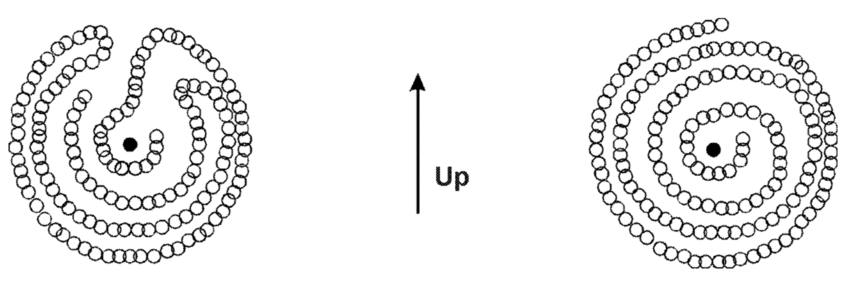


Figure D4-3. Heater orientation

D4.3.1.6.4 Heat-Flux Density Gauge

An air-cooled heat-flux density gauge will be provided for calibrating the output of the radiant heat furnace. The heat-flux density gauge will be a circular foil type, the operation of which was described by R. Gardon in “An Instrument for the Direct Measurement of Intense Thermal Radiation,” Review of Scientific Instruments, Vol. 24, 1953, pp.360-370.

NOTE: A thermocouple system capable of measuring 200° ± 2°F is an acceptable alternate method to monitor the body temperature of the heat-flux density gauge.

D4.3.1.6.4.1 Compressed air at a pressure of 15–30 psi (0.1–0.21 MPa) will be provided to cool the heat-flux density gauge. The body temperature of the heat-flux density gauge will be monitored with a thermometer having an accuracy of 2°F (1°C) at 200°F (93°C) in a 0.5- by 0.5- by 1.5-inch-long (13- by 13- by 38-mm) brass or copper well drilled to accept the thermometer with a close fit. Silicone grease will be used to provide good thermal contact. The circular receiving surface of the heat-flux density gauge will be spray coated with an infrared-absorbing black paint. The heat-flux density gauge will be calibrated calorimetrically using a procedure that is acceptable to the FAA Administrator.

D4.3.1.7 Pilot Burner

The pilot burner will be a multiple flamelet type with six tubes, as shown in figure D4-4. The six tubes will be fabricated from stainless-steel tubing having an outer diameter of 0.125 inch (3.2 mm) and an inner diameter of 0.055 inch (1.4 mm) ± 0.001 inch (0.025 mm). The six tubes will be attached to a common manifold, as shown in figure 6-4, fabricated from stainless-steel tubing having an outer diameter of 0.25 inch (6.4 mm) and a wall thickness of 0.035 inch (0.9 mm). One end of the manifold will be closed, and the other end will be attached to a gas-supply fitting on the chamber floor.

NOTE: The pilot burner should be aligned with a sample holder and backing board in place. A description of a suitable method of alignment is shown in figure D4-4. Care should be taken to ensure accurate positioning of the pilot tips to the sample holder.

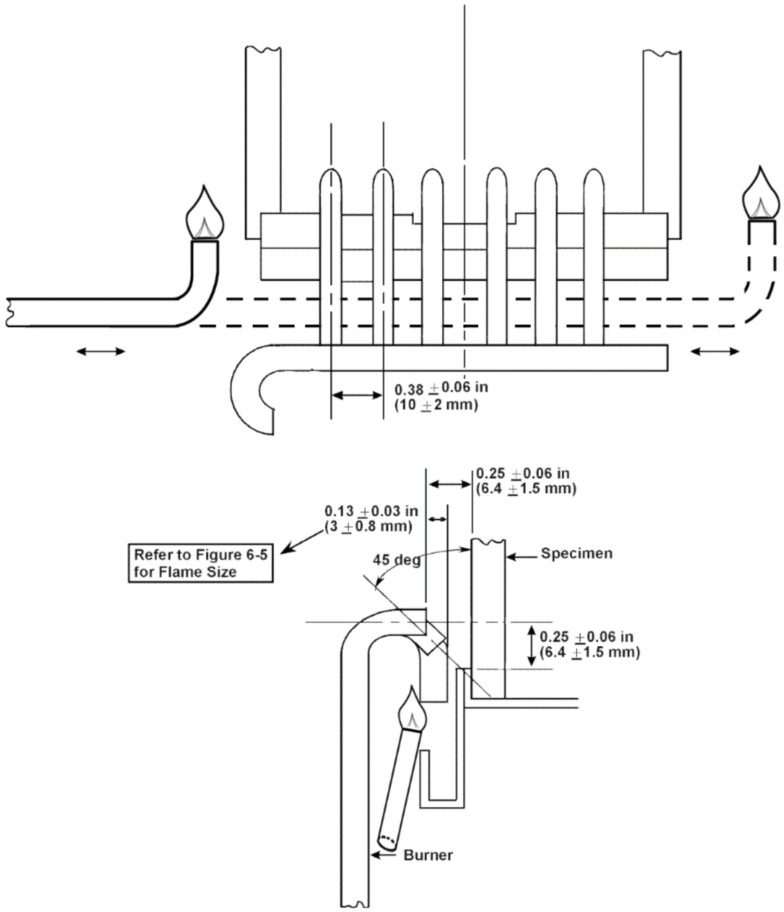


Figure D4-4. Alignment of holder and burner

D4.3.1.7.1 The two outer tubes of the pilot burner will be directed perpendicular to the surface of the specimen. The two inner tubes will be directed at an angle of 45 degrees downward. The two intermediate tubes will be directed vertically downward into the drip pan of the specimen holder.

D4.3.1.7.2 The pilot burner will be centered in front of and parallel to the specimen holder. The tips of the two outer tubes will be placed 0.25 ± 0.06 inch (6.4 ± 1.5 mm) above the lower opening of the specimen holder and 0.25 ± 0.06 inches (6.4 ± 1.5 mm) away from the face of the specimen surface.

D4.3.1.8 Pilot Burner Fuel

The gas fuel for the pilot burner will be prepared by mixing filtered oil-free air with 95 percent minimum-purity propane. This mixture will then be fed to the pilot burner. Each gas will be metered through separate, calibrated flowmeters and needle valves. The air-propane mixture will consist of an airflow rate equivalent to 0.018 ± 0.001 ft^3/min (500 ± 20 cm^3/min) at STP and a propane flow rate equivalent to 0.0018 ± 0.0001 ft^3/min

(50 ± 3 cm^3/min) at STP. The compressed air supply will be fed to its flowmeter at 20 ± 5 psi (0.14 ± 0.03 MPa) and the propane at 15 ± 3 psi (0.1 ± 0.02 MPa).

NOTE: Commercially bottled propane has been found acceptable.

D4.3.1.8.1 The visible parts of the pilot burner flamelets should be approximately 0.25 inch (6 mm) long with a luminous inner cone approximately 0.13 inch (3 mm) long, as shown in figure D4-5. If the flamelets are not that approximate size, there is probably difficulty with the air/propane fuel mixture or flow rate(s), in which case the accuracy of the flowmeters should be checked.

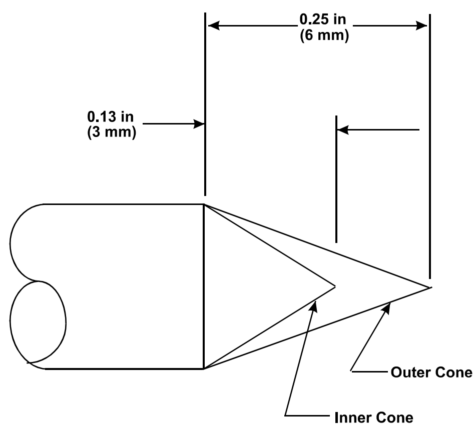


Figure 6-5. Flame Size

Figure D4-5. Flame size

D4.3.1.9 Specimen Holder

The specimen holder will consist of a stainless-steel frame, a backing made of insulation millboard, a spring and retaining rod to secure the specimen in place, and aluminum foil for wrapping the specimen.

D4.3.1.9.1 Specimen-Holder Frame

The specimen-holder frame will be fabricated of stainless-steel sheet by bending and brazing (or spot welding) a stainless-steel sheet of 0.025 ± 0.002 inches (0.64 ± 0.05 mm) nominal thickness to conform in shape and dimension to figure D4-6. The frame will be at least 1.5 inches (38 mm) deep and will provide an exposed specimen surface that is nominally 2.56 by 2.56 inches (65- by 65 mm) and that is at least 6.5 $inches^2$ (4194 mm^2) in area.

NOTE: Mounting the wire through holes made in the drip pan attachment mount between the top of the drip pan and the bottom of the holder across the face of the *specimen and over the top of the holder, and through holes made in the flange of the top guide just above the top of the holder, has been found satisfactory. This scheme permits the use of only one piece of wire threaded through the four holes with the two ends twisted together behind the guide at the top of the holder.*

Sample holders must be checked for accuracy with each other (e.g., top and bottom mounting devices consistent with each other). It has been noted that misalignment between holders does result in pilot position errors.

D4.3.1.9.1.1 A drip pan to catch and retain dripping material will be attached to the bottom front of the holder.

D4.3.1.9.1.2 Guides to permit accurate alignment of the exposed specimen area in front of the furnace opening will be attached to the top and bottom of the holder frame.

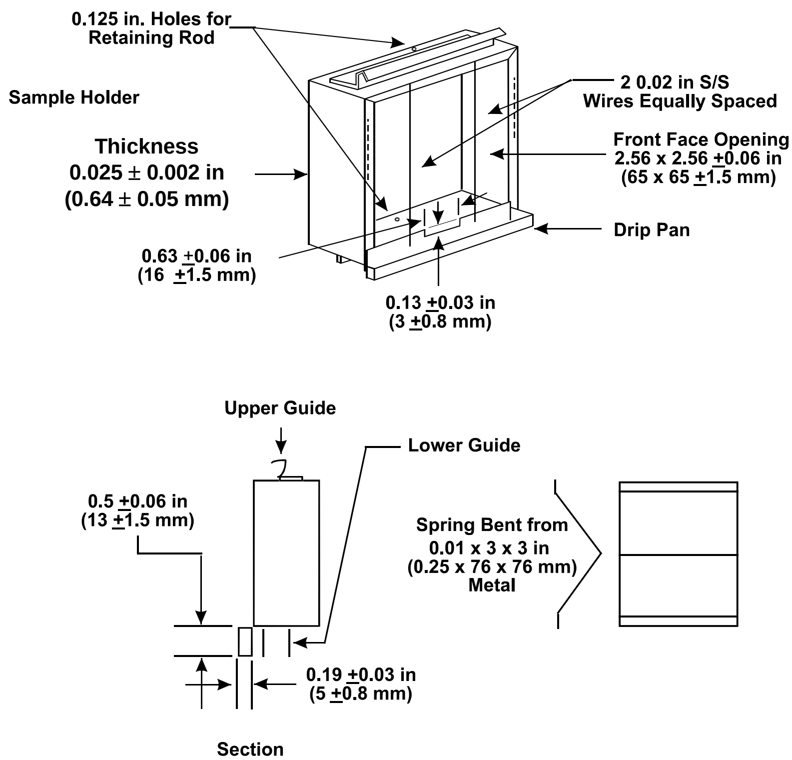


Figure D4-6. Details of specimen holder

D4.3.1.9.1.3 Two wires made of 0.02 ± 0.005-inch (0.5 ± 0.12-mm) diameter stainless steel, vertically oriented and evenly spaced (0.85 inch from the edge of the holder's vertical face openings and 0.85 inch from each other), will be attached to the holder face.

D4.3.1.9.2 Specimen Backing

A piece of insulation millboard will be used as a backing for the specimen and as a simulated blank specimen. The millboard will be nominally 0.5 inch (13 mm) thick with a density of 50 ± 10 lb/ft^3 (0.8 ± 0.16 g/cm^3) or equivalent. Pieces will be cut 2.91 ± 0.03 inches by 2.91 ± 0.03 inches (74 ± 1 mm by 74 ± 1 mm) to fit inside the specimen holder.

NOTE: A recommended material is Marinite I.

D4.3.1.9.3 Retaining Spring

A spring bent from a 3- by 2.94-inch thick by 0.01-inch thick (76- by 75- by 0.25-mm) stainless-steel sheet will be used with a stainless-steel retaining rod to securely hold the specimen and millboard backing in position during testing.

D4.3.1.9.4 Aluminum Foil

Smooth aluminum foil that is 0.0012 ± 0.0005 inch (0.03 ± 0.01 mm) thick will be used to wrap test specimens prior to their insertion in the holder.

NOTE: Aluminum foil used for household food wrapping is acceptable.

D4.3.1.10 Support for Radiant Heat Furnace and Specimen Holder

A typical support frame to support the radiant heat furnace and specimen holder is shown in figure D4-7. This support frame will have a provision to establish accurate alignment for the furnace opening so that it is 1.5 ± 0.031 inches (38 ± 1 mm) away from, parallel to, and centered with the exposed specimen surface. Adjustment screws will be provided to align the furnace with reference to the specimen.

The framework will have two 0.38-inch (10-mm) diameter transverse rods of stainless steel to accept the guides of the specimen holder. The rods will support the holder so that the exposed specimen surface is parallel to the furnace opening. Spacing stops will be mounted at both ends of each rod to permit rapid and accurate lateral positioning of the specimen holder. An externally operated control rod will be provided to replace the test specimen with the blank specimen holder in front of the furnace

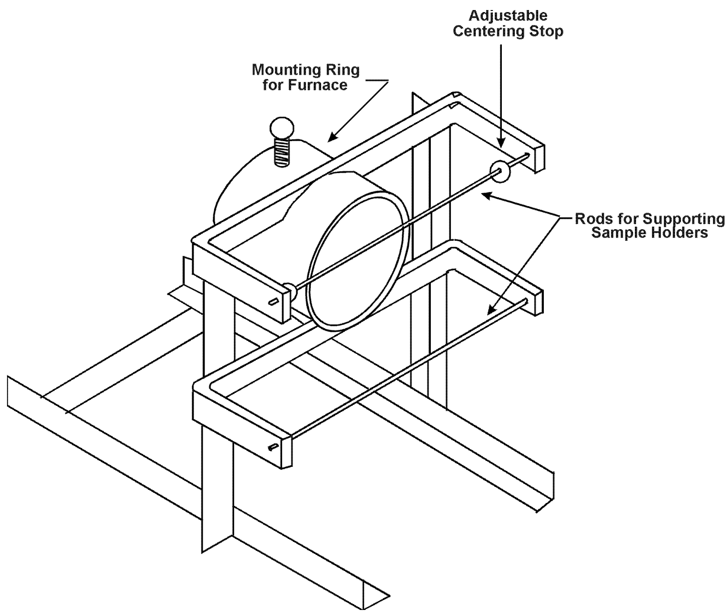


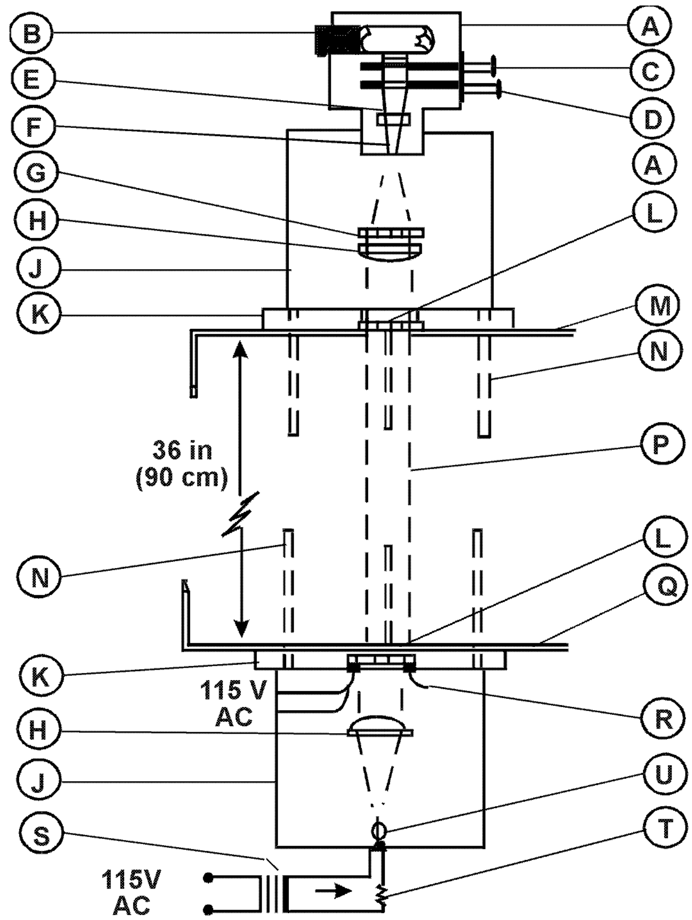
Figure D4-7. Typical furnace support

D4.3.1.11 Photometric System

A photometric system capable of detecting light transmittance values of 1 percent minimum to an accuracy of 3 percent will be provided. The system will consist of a light source and photomultiplier tube that are oriented vertically to reduce measurement variations due to stratification of the smoke in the chamber during the test, a photomultiplier microphotometer that converts the photomultiplier tube output to relative intensity or optical density, and a strip chart recorder or other suitable means to record light transmission versus time. A typical system is shown in figures D4-8 and D4-9.

D4.3.1.11.1 Light Source

The light source will be an incandescent lamp mounted in a sealed, light-tight box below the chamber floor, operated at a light brightness temperature of 2200 ± 100 K, controlled by a constant-voltage transformer. The box will contain the necessary optics to produce a collimated light beam, 1.5 ± 0.13 inches (38 ± 3 mm) in diameter, passing vertically up through the chamber. The light source and its optics will be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber bottom panel and sealed to prevent leakage of chamber contents. To minimize smoke condensation, the window will be provided with a ring-type electric heater mounted in the light-tight box, out of the light path, that maintains a minimum window temperature of 125°F (52°C) on the surface of the window inside the chamber.



A - Photomultiplier Housing
B - Photomultiplier Tube and Socket
C - Upper Shutter Blade with ND2 Filter over One Aperture
D - Lower Shutter Blade with Single Aperture
E - Opal Diffuser Filter
F - Aperture Disk
G - Neutral Density Compensating (from set of 9)
H - Lens 7 Diopter (2)
J - Optical System Housing (2)
K - Optical System Platform (2)
L - Optical Windows
M - Chamber Roof
N - Alignment Rods (2)
P - Parallel Light Beam 1.5 in (37.5 mm) Diameter
Q - Chamber Floor
R - Optical Window Heater, Silicone
S - Regulated Light Source Transformer, 115/125 V-6 V
T - Adjustable Resistor, Light Source Adjusted for 4V
U - Light Source

Figure D4-8. Photometer detail

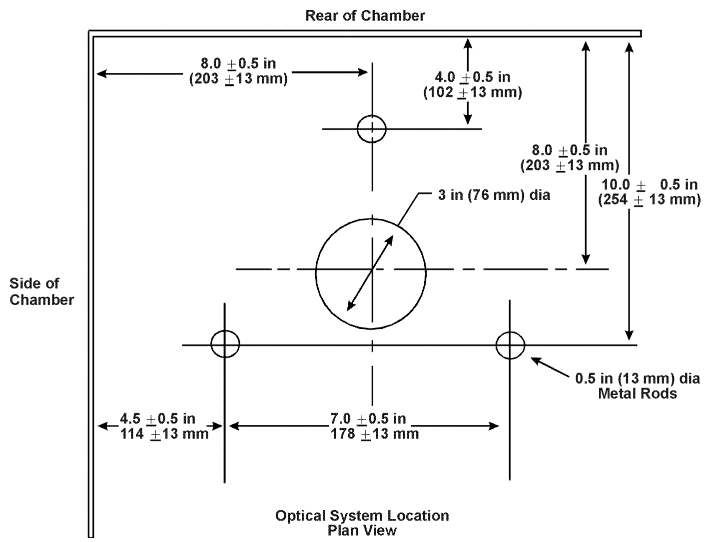


Figure D4-9. Photometer location

D4.3.1.11.2 Photomultiplier Tube

The photomultiplier tube will have an S-4 linear spectral response and a dark current of less than 10^{-9} amperes.

NOTE: A thin sheet of transparent material may be placed over optical and viewing windows to protect them from corrosive components in the smoke.

D4.3.1.11.2.1 The photomultiplier tube and associated optics will be mounted in a second light-tight box that is located above the chamber ceiling directly opposite the light source. The photomultiplier tube and its optics will be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber ceiling panel. The window, which permits viewing a cross section of 1.5 ± 0.13 inches (38 ± 3 mm), will be sealed to prevent leakage of chamber contents.

D4.3.1.11.3 Microphotometer

The microphotometer will be capable of converting the signal from the photomultiplier tube to relative intensity and/or to optical density. The microphotometer/photomultiplier tube combination will be sensitive enough that the microphotometer can be adjusted to produce a full-scale reading (100 percent relative light intensity or optical density = 1) using the photomultiplier tube's response (output) to the light source when a filter of 0.5 or greater optical density is placed in the light path.

D4.3.1.11.4 Alignment Fixture

The two optical windows and their housings will be kept in alignment and spaced 36 ± 0.125 inches (914 ± 3 mm) apart with an alignment fixture consisting of three metal rods 0.5–0.75 inch (13–19 mm) in diameter fastened securely to 0.31-inch-thick (8-mm) externally mounted top and bottom plates and symmetrically arranged about the collimated light beam.

D4.3.1.11.5 Optical Filters

A set of nine neutral color optical filters of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 optical density will also be provided. The optical filters, one or more as required, may be mounted in the light path in the optical measuring system to compensate for the sensitivity of the photomultiplier tube. These filters may also be used to adjust the photometric system as the light source/photomultiplier tube change sensitivity through aging or as discoloration or deterioration of the optical windows occurs.

D4.3.1.11.6 Recorder

A recording device will be furnished that provides a record of the percent light transmission or optical density versus time during the test. The record will consist of either a continuous curve on a chart recorder or discrete values taken at least every 5 seconds with a computerized data-acquisition system.

D4.3.1.12 Exhaust Hood

A method for removing the chamber contents after each test will be provided. A fitting for removing the chamber contents may be connected to a suitable exhaust hood. Locating an exhaust hood directly above the smoke chamber door is recommended as an additional safety device.

D4.3.1.13 Conditioning Chamber

A conditioning chamber capable of maintaining test specimens at a temperature of 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity will be provided.

D4.3.2 Recommended Equipment

The following items are recommended but not required:

D4.3.2.1 Digital Voltmeter

A digital voltmeter is preferred to monitor furnace voltage and heat-flux density gauge output. A Keithley Model 165 Autoranging Multimeter or equivalent has been found acceptable.

D4.3.2.2 Constant Voltage Transformer

A constant voltage transformer is recommended for all installations (see section D4.3.1.5).

D4.3.2.3 Pilot Burner Positioning Fixture

A fixture to accurately position the pilot burner is recommended to establish a precise pilot burner position for testing and to facilitate accurate repositioning of the pilot burner after removal and replacement (see figure D4-10).

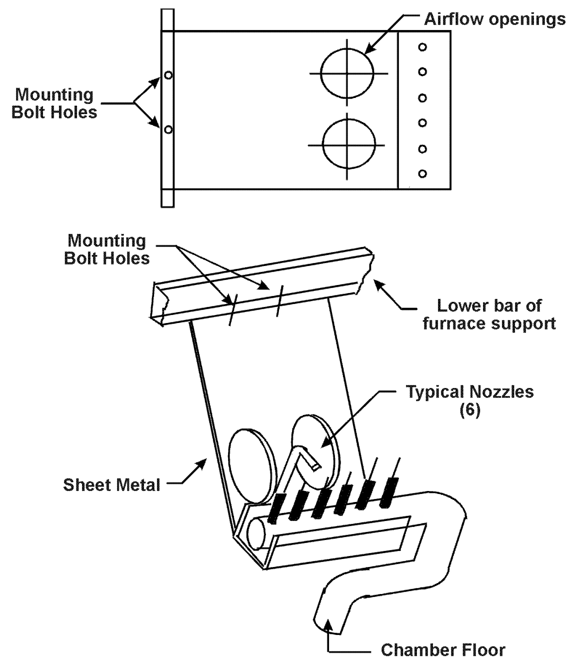


Figure D4-10. Burner position (optional)

A more precise positioning device is available from Newport Scientific. Its part number is 680860354000.

D4.3.2.4 Reignition System

A reignition system is recommended to relight the horizontal and 45-degree pilot burner flamelets to ensure that none of them extinguish for more than 3 seconds during the test. The preferred method of reignition is a manually operated sliding tube, with a propane and air mix, adjusted to impinge on the pilot outlets as it is moved across an area adjacent to the pilot flames. A method of operating this could be made similar to the device in the smoke chamber that moves the sample, such as a push-pull rod (see figure D4-4). If an electric sparking device is used, an appropriate method of suppression and equipment shielding must be applied to have no interference with the ability of the data-acquisition equipment to accurately record data.

D4.4 Test-Specimen Selection and Preparation

D4.4.1 Specimen Number

A minimum of three specimens will be prepared and tested for each part/construction.

NOTE: Conditions may require as many as six specimens. For test purposes, specimens should be marked with an arrow for a consistent direction by manufacturers or operators.

D4.4.2 Specimen Selection

Specimens will either be taken from an actual part or built to simulate a part.

D4.4.2.1 Flat sections of the same thickness and composition may be tested in place of curved, molded, or specialty parts.

D4.4.2.2 Both faces of a multilayer assembly will be tested as a separate part/construction if the outer materials are different on the faces and if both sides are exposed to the passenger cabin interior. If both faces must be tested, two sets of specimens will be provided.

D4.4.3 Specimen Size

Each specimen will be 2.9 ± 0.06 inches by 2.9 ± 0.06 inches (73 ± 2 mm by 73 ± 2 mm). The specimens will be the same thickness as the thickness of the part/construction.

D4.4.4 Specimen Orientation

For materials that may have anisotropic flammability properties (i.e., different properties in different directions, such as machine and cross-machine directions for extrusions, and warp and fill directions of a woven fabric), specimens will be tested in the orientation thought to give the highest result. If the average ${}^4D_m$ is greater than 180, a second set of specimens will be prepared and tested in the orientation that is perpendicular to the orientation used for the first set of specimens. The higher of the two average ${}^4D_m$ values will be reported.

D4.4.5 Specimen Preparation

All surfaces of the specimen, except the surface to be exposed for the test, will be wrapped with aluminum foil (see section D4.3.1.9.4) prior to placing them in a specimen holder. The side of the foil with dull finish will be placed next to the specimen. After the specimen is placed in a specimen holder, any aluminum foil on the exposed specimen will be removed from the bottom (to avoid interference with the pilot burner flamelets) and either removed or folded back on the other three sides (to avoid covering any of the exposed specimen surface area). The specimen will be placed in a holder, followed by an alumina-silica backing board, the spring plate, and the retaining rod (see figure D4-6).

D4.5 Specimen Conditioning

D4.5.1 Specimens will be conditioned at a temperature of 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for a minimum of 24 hours, unless otherwise specified. Only one specimen at a time will be removed from the conditioning chamber. When removed, the specimen will be immediately tested.

D4.6 Test Chamber Calibration

D4.6.1 Furnace Protection

Prepare a blank specimen consisting of 0.5-inch-thick alumina-silica millboard (see section D4.3.1.9.2) mounted in a specimen holder. To reduce problems with the stability of the heat-flux density from the furnace, maintain the blank specimen in front of the furnace when no testing or calibration is being conducted.

D4.6.2 Periodic Calibration Procedure

Conduct a periodic calibration of the system as follows:

D4.6.2.1 Photometric System

The photometric system used in this test method is an inherently linear device. Check the system for proper photocell alignment. Verify, at least every 2 months, the linearity of the system using a set of neutral optical density filters or the equivalent. Check the system more frequently if erratic behavior is observed or suspected.

D4.6.2.2 Furnace

Use the approved heat-flux density gauge to monitor the heat-flux density produced by the furnace. Place the heat-flux density gauge on the horizontal rods of the furnace support framework and accurately position it in front of the furnace opening by sliding and displacing the blank specimen holder against the spacing stop (see section D4.3.1.10). With the chamber door closed and the inlet vent opened, adjust the compressed air supply to the heat-flux density gauge cooler to maintain its body temperature at 200° ± 50°F (93° ± 3°C). Adjust the setting of the furnace control voltage or power controller to obtain the calibrated millivolt output of the heat-flux density gauge corresponding to a steady-state irradiance of 2.5 ± 0.05 W/cm^2 (2.2 ± 0.04 Btu/ft^2*sec). After the irradiance has reached the required value and has remained steady-state for at least 5 minutes, remove the heat-flux density gauge from the chamber and replace it with the blank specimen holder.

D4.6.2.2.1 Record the setting of the furnace control voltage or power controller and use this setting until a future calibration indicates it should be changed.

D4.6.2.3 Chamber Leak Test

Test the smoke density chamber leak rate at least once a month, or more often if loss of chamber pressure is suspected, using the following procedure:

D4.6.2.3.1 Close the inlet vent and the chamber door.

D4.6.2.3.2 Pressurize (e.g., by bleeding in a small amount of air through the port used for the heat-flux density gauge) the chamber to at least 3 inches of water above ambient, as indicated by the manometer.

D4.6.2.3.3 Note the chamber pressure. Verify that the chamber pressure leakage rate is less than 2 inches of water in 2 minutes.

D4.6.2.4 Total System

Check the total system at least once a month by testing a material that has shown a consistent specimen-to-specimen ${}^4D_m$ value in the range of 150–220 ${}^4D_m$ and that is, and will continue to be, readily available. Maintain a record of the test results obtained. If erratic values are observed, identify and correct any instrumental or operational deficiencies.

D4.6.3 Chamber Cleaning

Clean the optical system windows, viewing window, chamber walls, and specimen holders as follows:

D4.6.3.1 Optical System Windows

Clean the exposed surfaces of the glass separating the photo detector and light source housings from the interior of the chamber after each test. Clean the top window first, then the bottom window, using a nonabrasive cloth dampened with a suitable cleaner. Dry the window to prevent streaking or film buildup. Do not use any cleaners that contain wax because wax will cause the smoke to adsorb to the glass more quickly.

NOTE: Ethyl alcohol, methyl ethyl ketone, or equivalent has been found satisfactory.

D4.6.3.2 Viewing Window

Clean the viewing window periodically as required to allow viewing the chamber interior during testing. The cleaners used in section D4.6.3.1 have been found satisfactory.

D4.6.3.3 Chamber Walls

Clean the chamber walls periodically to prevent excessive buildup of smoke products. An ammoniated spray detergent and nonabrasive scouring pad have been found effective.

D4.6.3.4 Specimen Holders

Remove any charred residue on the specimen holders and horizontal rods securing the holder position to prevent contamination of subsequent specimens.

D4.7 Test Procedure

D4.7.1 Each day, prior to testing, adjust the chamber as follows:

D4.7.1.1 Calibrate the furnace output according to section D4.6.2.2 to determine the correct furnace voltage.

D4.7.1.2 Balance the photomultiplier dark current and set the clear beam reading to 100 percent relative transmission or to optical density 0.00.

NOTE: This procedure is described in AMINCO NBS Smoke Density Chamber, Catalog No. 4-5800B, Instruction 941B.

D4.7.1.3 Set the photomultiplier scale at 100. Shut the lower shutter blade (D) directly below photomultiplier tube (B) (see figure D4-8). Set 0 on the data-recording device.

NOTE: During testing at the FAA William J. Hughes Technical Center, a software-related problem was discovered with the calculation of D_s during some NBS chamber testing. It is possible that during the initial readings taken with a blanked off photocell, there should be some residual voltage reading (± 1 millivolt). This is too small a value to be read visually but can be detected by the computer. The problem is that current software assumes the initial value is 0 and the results are altered accordingly. Because the specific optical density is a logarithmic function, the problem is magnified by the higher value, making the D_s at the approximate pass/fail point of 200 critical. A ± millivolt initial reading can change an actual D_s of 200 to 175/224, respectively. The fix for this problem is to blank off the photocell prior to each test and let the computer set the "zero."

Computer users could use the following procedure for the computer program: close the shutter, let the computer read baseline volts (0) (mV_b), and determine:

$$\text{Slope} = \frac{100}{(mV_H - mV_b)}$$

$$\%L.T. = (mV - mV_b) * \text{Slope}$$

D4.7.2 Conduct the test procedure as follows:

D4.7.2.1 Ensure that the specimen(s) have been properly prepared per sections D4.4.1 through D4.4.5.

D4.7.2.2 Ensure that the chamber wall temperature is 95° ± 4°F (35° ± 2°C).

D4.7.2.3 Ensure that the furnace voltage has been set correctly.

D4.7.2.4 Set the clear beam reading to 100-percent relative transmission or to optical density 0.00. See section D4.7.1.2.

D4.7.2.5 Position the pilot burner in front of and parallel to the specimen holder. Turn on the pilot burner fuel (see section D4.3.1.8), and light the flamelets on the pilot burner. Make sure all flamelets are ignited and properly adjusted.

D4.7.2.6 Remove a test specimen from the conditioning chamber, open the test-chamber door, and place the specimen holder on the support. Immediately push the specimen holder into position in front of the furnace, displacing the blank specimen holder to the prepositioned stop, and close the chamber door and inlet vent. For chambers with an external device to move the specimen holder in front of the furnace, place the holder on the support, close the door, slide the sample into position, and simultaneously start the timer and recorder for light transmission.

D4.7.2.7 Continue the test for a minimum of 4 minutes (240 seconds). Do not perform any analysis of the chamber contents, such as gas sampling, during the first 4 minutes (240 seconds) of testing.

D4.7.2.8 Record the percent light transmission/optical density versus time (minutes) during the test.

D4.7.2.9 Monitor the chamber pressure during the test. If negative pressure (below ambient atmospheric) develops, open the inlet valve slightly to relieve negative pressure.

D4.7.2.10 Monitor the pilot burner flamelets during the test. Note and record if either of the outer flamelets oriented perpendicular to the specimen surface or if either of the inner flamelets oriented 45 degrees to the specimen surface extinguish and remain continuously extinguished for more than 3 seconds. If such extinguishing occurs, the test results from that specimen are not valid, and the test may be terminated and another test started with a new test specimen.

D4.7.2.11 At the termination of the test, remove the test specimen holder from its position in front of the furnace, and replace it with the blank specimen holder using the exterior control rod. Begin exhausting the chamber of smoke within 1 minute by opening the door and the inlet vent (and exhaust vent, if used).

CAUTION: The door should be opened gradually to avoid exposure to the chamber contents, which may be toxic.

D4.7.2.11.1 Continue to exhaust the chamber until all smoke has been removed.

D4.7.2.12 Clean the windows to the housings for the photomultiplier tube and the light source per section D4.6.3.1.

D4.7.2.13 Calculate and record the maximum specific optical density, ${}^4D_m$, during the 4-minute (240-second) test for each specimen according to the formula:

$$
\begin{aligned}
{}^4D_m &= (V / LA)\log_{10}\left(100/{}^4T_m\right) \\
&= 132 \log_{10}\left(100/{}^4T_m\right)
\end{aligned}
$$

where:

V = chamber volume = 18.00 ft^3 (0.510 m^3)

L = light path length = 3.00 ft (0.914 m)

A = exposed specimen area = 6.57 in^2 (0.00424 m^2)

^4T = minimum percent light transmission during 4 minutes

$\log_{10}(100/{}^4T_m)$ = maximum optical density during 4 minutes

D4.7.2.14 Calculate and record the average ^4D_m value and its standard deviation for all the specimens tested for each part/construction. Use the actual ^4D_m values for this average. Do not use the average light transmission value to determine the average ^4D_m value.

D4.8 Report

D4.8.1 Report a complete identification of the part/construction tested, such as material construction, thickness, and weight.

D4.8.2 Report the number of specimens tested and the average ^4D_m.

D4.8.3 Report any additional data or observations as applicable/required by the test plan.

D4.9 Requirements

D4.9.1 Per 14 CFR 25.853(c) through (1), amendment 25-72, the average ^4D_m during the 4-minute test will not exceed 200.

Chapter D5
Oil Burner Test for Seat Cushions

D5.1 Scope

D5.1.1 Applicability

This test method evaluates the burn-resistance and weight-loss characteristics of aircraft seat cushions when exposed to a high-intensity open flame to show compliance with the requirements of 14 CFR 25.853.

D5.2 Definitions

D5.2.1 Burn Lengths

The four principal burn lengths are measured along the top side of the horizontal seat cushion, bottom side of the horizontal seat cushion, front side of the vertical seat cushion, and the back side of the vertical seat cushion. The four burn lengths are defined as the distance measured in inches from the edge of the seat frame nearest the burner to the farthest point where damage to the test specimen occurred because of that area's combustion. That includes partial or complete consumption, charring, or embrittlement, but does not include areas sooted, stained, warped, or discolored.

D5.2.2 Percentage Weight Loss

The percentage weight loss for a specimen set is the pretest weight of the specimen set less the posttest weight of the specimen set expressed as the percentage of the pretest weight. All droppings falling from the specimens and mounting stand are to be discarded prior to determining the posttest weight.

D5.2.3 Back Cushion Specimen

The back cushion specimen is the cushion specimen in the vertical orientation. This specimen may be representative of the production seat back, seat bottom, or both, if the production articles have the same construction.

D5.2.4 Bottom Cushion Specimen

The bottom cushion specimen is the cushion specimen in the horizontal orientation. This specimen may be representative of the production seat back, seat bottom, or both, if the production articles have the same construction.

D5.2.5 Specimen Set

A specimen set consists of one back cushion specimen and one bottom cushion specimen. Both specimens represent the same production cushion construction; that is, both specimens in the specimen set have identical construction and materials proportioned to correspond to either the actual seat bottom or back cushion but not both. For various reasons, seat bottom and back cushions on actual seats are typically as installed in the airplane.

D5.3 Apparatus

D5.3.1 Test Apparatus

The arrangement of the test apparatus is shown in figures D5-1 and D5-2, and includes the components described in this section. The burner stand has the capability of moving the burner away from the test specimen during warmup.

D5.3.2 Test Burner

The burner will be a modified gun type, such as Park Model DPL 3400, Lennox Model OB-32, or Carlin Model 200 CRD. Flame characteristics can be enhanced by the optional use of a static disk or tabs. (See static disk in the supplement to this chapter.) Major deviations, such as a different burner type, require thorough comparison testing. Temperature, heat-flux measurements, and test results must correspond to those produced by an FAA-approved burner.

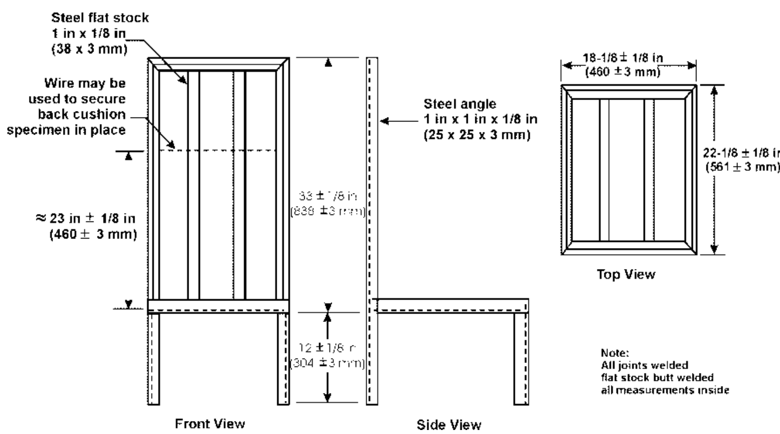


Figure D5-1. Front, side, and top views of seat oil burner specimen frame

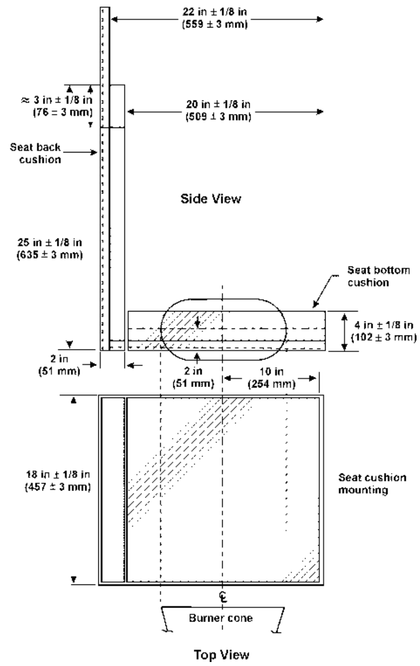


Figure D5-2. Top and side view of specimen setup in test frame

D5.3.2.1 Nozzle

The nozzle used for the burner is required to maintain a fuel pressure that will yield a 2 ± 0.1 gal/hr (0.126 L/min ± 0.0063 L/min) fuel flow.

NOTE: A Monarch 80-degree AR or 80-degree R nozzle nominally rated at 2.25 gal/hr (0.142 L/min) at 100 lb/in^2 (0.71 MPa) and operated at an 85 lb/in^2 (0.6 MPa) gauge has been found to deliver 2 gal/hr (0.126 L/min) and produce a proper spray pattern. A Monarch 80-degree Constant Capacity (CC) nozzle, nominally rated at 2 gal/hr at 100 lb/in^2, and operated between 95 and 105 lb/in^2 gauge, is also acceptable. Minor deviations to the fuel-nozzle spray angle, fuel pressure, or other similar parameters are acceptable if the fuel-flow rate, temperatures, and heat-flux measurements conform to the requirements of sections D5.6 and D5.7.

D5.3.2.2 Burner Cone

A 12 ± 0.125-inch (305 ± 3-mm) burner cone extension will be installed at the end of the draft tube. The cone will be made of stainless steel or a similar type of noncorrosive high-temperature metal and will have a thickness of 0.065 ± 0.015 inch (1.65 ± 0.381 mm). The opening of the cone will be 6 ± 0.125 inches (152 ± 3 mm) high and 11 ± 0.125 inches (280 ± 3 mm) wide (see cone in figures D5-3a and D5-3b).

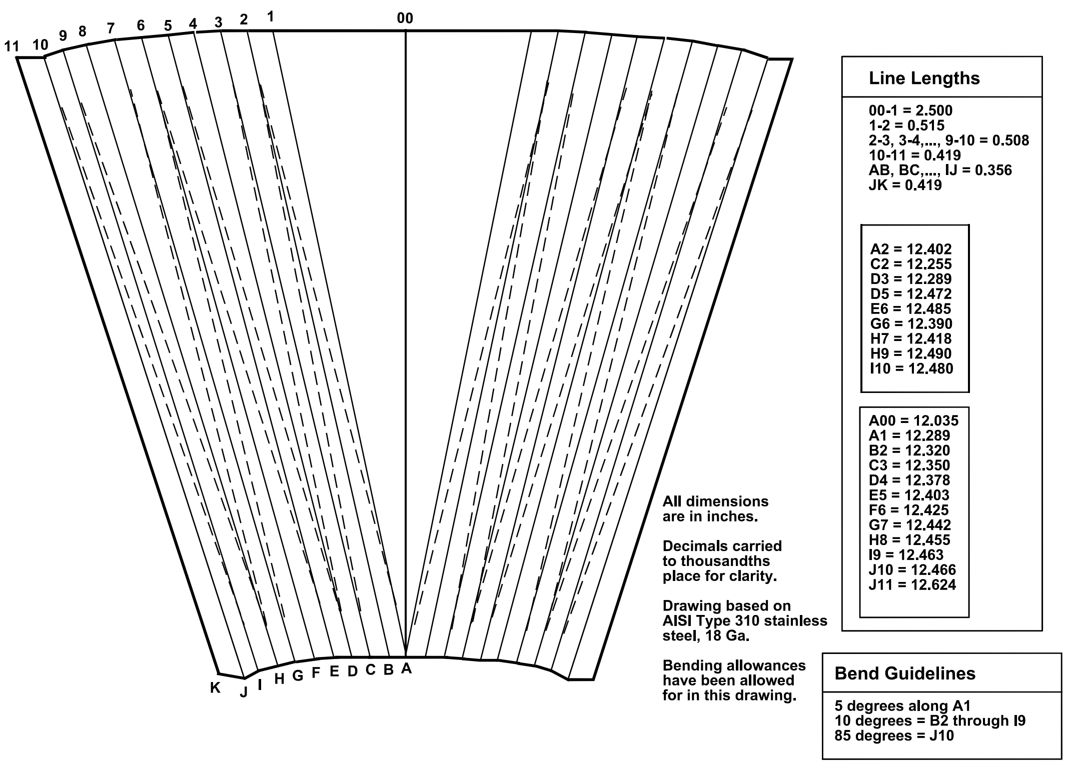


Figure D5-3a. Burner cone layout and bending pattern

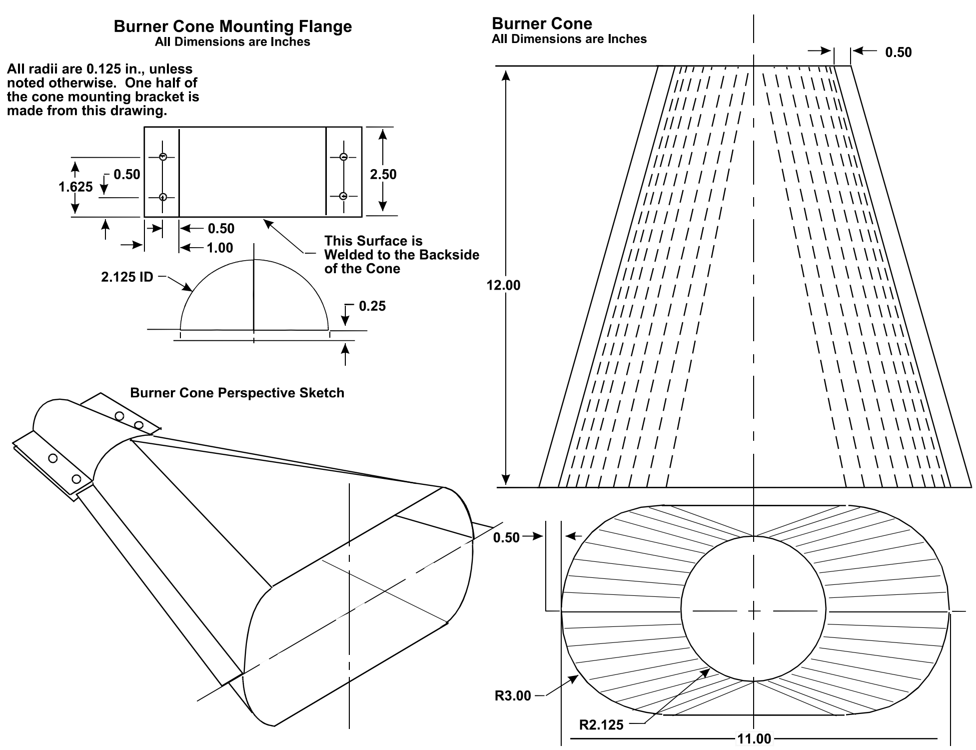


Figure D5-3b. Burner and cone details

D5.3.2.3 Fuel

ASTM K2 fuel (number 2 grade kerosene) or ASTM D2 fuel (number 2 grade fuel oil) will be used.

NOTE: Number 2 diesel fuel, Jet A, or the international equivalent, is the recommended fuel because it has been found to produce satisfactory results if the fuel-flow rate and inlet airflow conform to the requirements of sections D5.6 and D5.7.

D5.3.2.4 Fuel-Pressure Regulator

A fuel-pressure regulator adjusted to deliver 2 gal/hr ± 0.1 gal/hr (7.57 L/hr ± 0.38 L/hr) will be provided.

NOTE: A fuel-pressure regulator adjusted to deliver 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min) flow through the nozzle should be provided. An operating fuel pressure of 85 ± 4 psig (0.57 ± 0.03 MPa) for a 2.25 gal/hr (0.142 L/min) 80-degree spray angle nozzle has been found satisfactory.

D5.3.2.5 Anemometer

A vane-type air-velocity sensing unit will be used to monitor the flow of air at the inlet of the oil burner. The inlet will be completely sealed, except for an opening for the air velocity sensor, where it will be centered and mounted (see anemometer setup in figure D5-4).

NOTE: The Omega microprocessor-based portable air-velocity kit, model HH-30, is a suitable unit. The unit monitors air velocity in feet per minute (FPM) or meters per second (MPS) ± 1% reading accuracy; therefore, necessary conversions must be made to attain airflow values. To do this, the area of the opening of the air sensor must be measured. Once the area is found, install the air velocity sensor at the oil burner inlet. Following the procedures prescribed in section D5.6.4, this value should be multiplied by the air-velocity reading. The Omega model HH-30 air-velocity sensor's area is 0.037 ft^2. (For example, to achieve an airflow of 67 ft^3/min, an air-velocity reading of 1811 ft/min must be maintained.)

Airflow = Air Velocity × Area of Opening (Air Velocity Sensor)

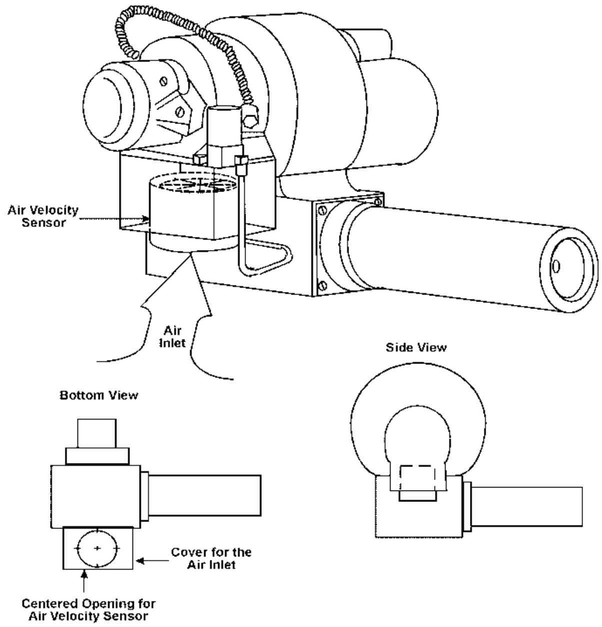


Figure D5-4. Illustration for the location of the air velocity sensor

D5.3.3 Heat Flux Gauge

The heat flux gauge (HFG) will be a total heat flux, foil-type Gardon gauge of an appropriate range, such as 0 to 15 Btu/(ft^2 sec) (0 to 17 W/cm^2), accurate to ± 3% of the indicated reading.

D5.3.3.1 Calorimeter Mounting

The HFG will be mounted in a 6 by 12 ± 0.125-inch (152 by 305 ± 3-mm) by 0.75-inch-thick (19 mm) insulating block that is attached to a steel angle bracket for placement in the test stand during burner calibration (see figure D5-5). The insulating block will be monitored for deterioration and replaced when necessary. The mounting will be shimmed as necessary to ensure that the calorimeter face is parallel to the exit plane of the test burner cone.

D5.3.4 Thermocouples

Seven 0.0625-inch-diameter, ceramic-packed, metal-sheathed, type K (chromel-alumel), grounded-junction thermocouples with a nominal 30 AWG-size conductor will be provided for calibration. The thermocouples will be attached to a steel bracket to form a thermocouple rake for placement in the test stand during burner calibration, as shown in figure D5-6.

NOTE: The thermocouples are periodically subjected to high temperatures during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases or extreme variations in temperature or no temperature reading at all are signs that the thermocouple or thermocouples are degrading, or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept of the amount of time the thermocouples are exposed to the oil burner's flame.

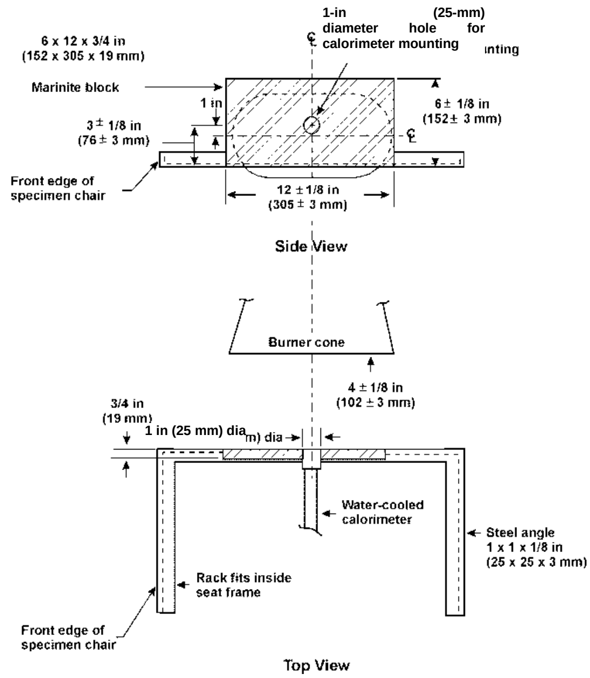


Figure D5-5. Top and side views of calorimeter bracket

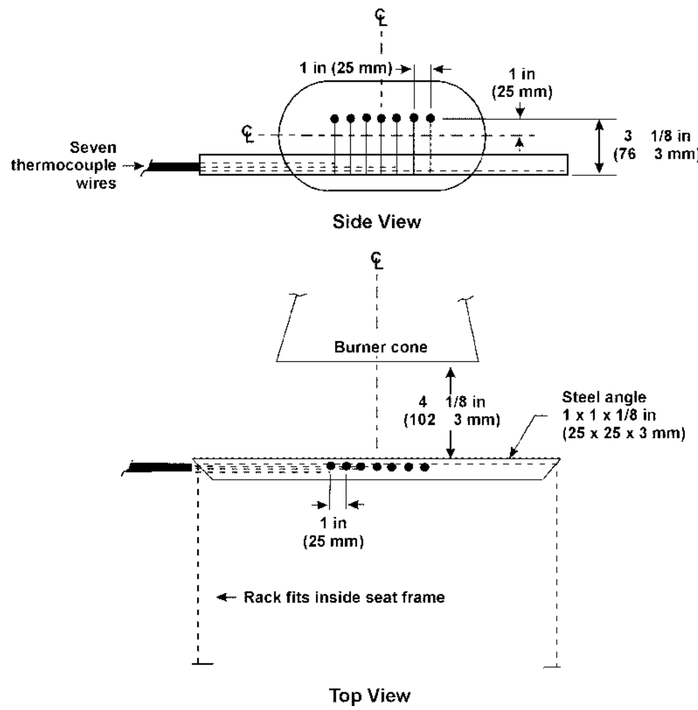


Figure D5-6. Top and side views of thermocouple rack bracket

D.3.5 Specimen Mounting Frame

The mounting frame for the test specimen will be fabricated of 1- by 1- by 0.125-inch (25 by 25 by 3 mm) steel angle, as shown in figure D5-1. A wire can be added to the mounting frame for the seat back cushion to secure the specimen into place. More than one wire may be used to restrain leather seat components if the wires do not impede or redirect the flame. The mounting stand will be used for mounting the test specimen seat bottom and seat back, as shown in figure D5-2.

NOTE: A length of wire can be used to aid in securing the vertical seat cushion to the specimen frame (see figure D5-2). The wire should be uninsulated, solid, 0.032 inch (0.8 mm) or less in diameter, and be located no more than 0.5 inch (13 mm) from the top surface of the vertical specimen as it sits in the frame. The wire should not disturb the flame-spread behavior of the material(s) being tested. If the flame spread is affected, another wire configuration should be used.

D5.3.5.1 Drip Pan

The mounting stand will include a suitable drip pan lined with aluminum foil, dull side up. The drip pan will be located at the bottom of the mounting stand legs, 12 ± 0.125 inches (305 ± 3 mm) below the horizontal specimen holder.

D5.3.6 Instrumentation

A calibrated recording device or a computerized data-acquisition system with an appropriate range will be provided to measure and record the outputs of the calorimeter and the thermocouples.

D5.3.7 Weight Scale

A weighing device will be provided to determine the pretest and posttest weights of each set of seat-cushion specimens within 0.02 lbs (9 g).

NOTE: A continuous weighing system is recommended because it allows the operator the ability to monitor weight loss during the test.

D5.3.8 Timing Device

A stopwatch or other device, accurate to ± 1 sec/hr, will be provided to measure the time of application of the burner flame and self-extinguishing time (or test duration).

D5.4 Test Specimens

D5.4.1 Specimen Preparation

A minimum of three specimen sets of the same construction and configuration will be prepared for testing.

D5.4.2 Seat Bottom (Horizontal) Cushion Specimen

The constructed, finished specimen assembly will be 18 + 0, -0.125 inches (457 + 0, -3 mm) by 20 + 0,-0.125 inches (508 + 0, -3 mm) by 4 + 0, -01.125 inches (102 + 0, -3 mm), exclusive of fabric closures and seam overlap.

D5.4.3 Seat Back (Vertical) Cushion Specimen

The constructed, finished specimen assembly will be 18 + 0, -0.125 inches (457 + 0, -3 mm) by 25 + 0, -0.125 inches (635 + 0, -3 mm), by 2 + 0, -0.125 inches (51 + 0, -3 mm), exclusive of fabric closures and seam overlap.

D5.4.4 Construction

Each tested specimen will be fabricated using the principal components (i.e., foam core, flotation material, fire-blocking material, if used, and dress covering) and assembly processes (representative seams and closures) intended for use in the production articles. If a different material combination is used for the production back cushion than for the production bottom cushion, both material combinations will be tested as complete specimen sets. Each set will consist of a back cushion specimen and a bottom cushion specimen (see figure D5-7).

D5.4.4.1 Fire-Blocking Material

If the cushion is constructed with a fire-blocking material, the fire-blocking material will completely enclose the cushion foam core material.

D5.4.4.1.1 Specimen Fire-Blocking Fabrication

The method of fabricating blocking layer seams and closures will be the same as the production method. In fabricating the test specimen, the fire blocker will be configured so that any possible weak point is exposed to the burner flame. This may require configuring a test specimen so that the seam is exposed to the test burner, even though a seam may not be located there on a production cushion.

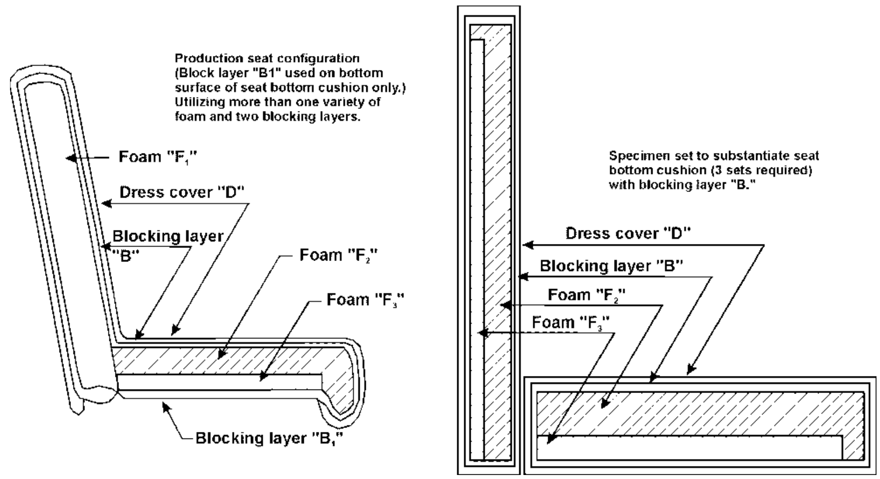


Figure D5-7. Example of production seat configuration and test specimen set to substantiate production seat bottom cushion

D5.4.4.1.2 Multiple Fire-Blocking Materials

If more than one fire-blocking layer material is used on a given production cushion, each blocking layer material will be subjected to this test procedure as separate test sets. The fire-blocking material will completely encapsulate the specimens so that all fire-blocking layers are subjected to the same level of test severity. Fire-blocking layers will not be used in combination for this test (see figure D5-8).

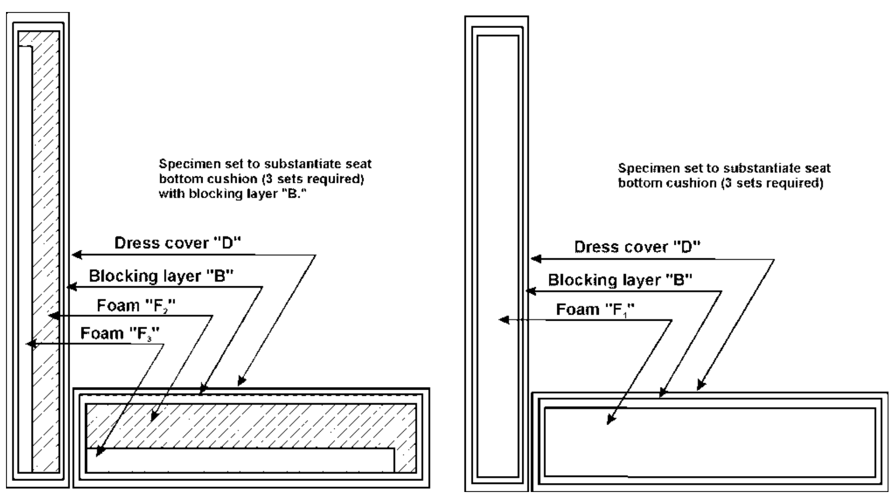


Figure D5-8. Specimen set to substantiate production seat bottom and specimen set to substantiate production seat back

D5.4.4.2 Foam

Seats that utilize more than one variety of foam (composition, density) will have specimen sets constructed that reflect the foam combination used.

NOTE: If several seat models use similar foam combinations, it is not necessary to test each combination if it is possible to bracket the various combinations. For example, if foam "A" makes up 80 percent and foam "B" makes up 20 percent of the foam volume in one seat model, and in another similar seat model, foam "A" makes up 20 percent and foam "B" makes up 80 percent of the foam volume, it is generally acceptable to approve all combinations of "A" and "B" foams between these limits if the 20/80 and 80/20 extremes are tested and pass. In addition, for foams of a given chemical composition, low-density foam can be used in lieu of foams of higher density. In this case, as in the case of foam combinations, all other elements that make up the cushion must be the same (see figure D5-7).

D5.4.4.3 Dress Covering

If a production seat construction uses more than one dress covering, the test configuration may be represented as shown in figure D5-9.

NOTE: When any seat construction tested has passed, a separate test is not required for another seat construction if the only difference from the first test is the dress covering, provided the replacement dress covering is comprised of a similar weave design and fiber type, as described in section D5.4.4.3.2; also, the burn length of the replacement dress covering, as determined by the Bunsen burner test specified in 14 CFR 25.853(b), cannot exceed the burn length of the dress covering used for the test.

Test specimens are intended to represent the principal material elements and construction methods of the production seats. Items decorative in nature, such as buttons, detail stitching, hand-hold straps, hook-and-loop attached strips, or thin outer-cover paddings—such as armrest covers and filler around food trays—that do not penetrate the fire-blocking layer when fastened, are not required to be represented on the test specimen. Dress cover details and items not associated with the cushion construction, such as metal seat pans or other metal structures, should not be included in the specimen weight because they are not part of the principal seat construction. Layers of padding or filler immediately under the dress cover material are considered to be part of the dress cover material and should be included in the test specimens.

Similar dress covering (from Advisory Circular 25.853-1, "Flammability of Aircraft Seat Cushions," Sections 5d[1] and [2]) refers to dress covering materials having the same material composition, weave style, and weight. Material blends can be considered similar when the constituent material fractions are the same, ± 6%, as the tested material. Examples of different weave styles include plain, jacquard, or velvet. With regard to weight, lighter fabrics are generally more critical than heavier fabrics. Because of the severe shrinking and unpredictable distortion experienced by leather dress cover materials, similarity approvals for leather are not recommended.

Certification by similarity to previously tested dress covers should be limited to instances in which the material composition is the same, and the weight and weave type are essentially the same. In all cases, results of the Bunsen burner test per 14 CFR 25.853(b) for the new material should be equal to or better with respect to burn length than the tested *material. In addition, it may be useful to evaluate the weight-loss and burn-length results of the oil burner test to determine if the tested material is a good basis for similarity (i.e., the closer weight loss and burn length with the oil burner are to the maximum allowed, the more alike the dress covering materials should be for similarity). In general, test data and resultant experience gained from conducting tests should also be major sources of information to determine if approval by similarity is acceptable.*

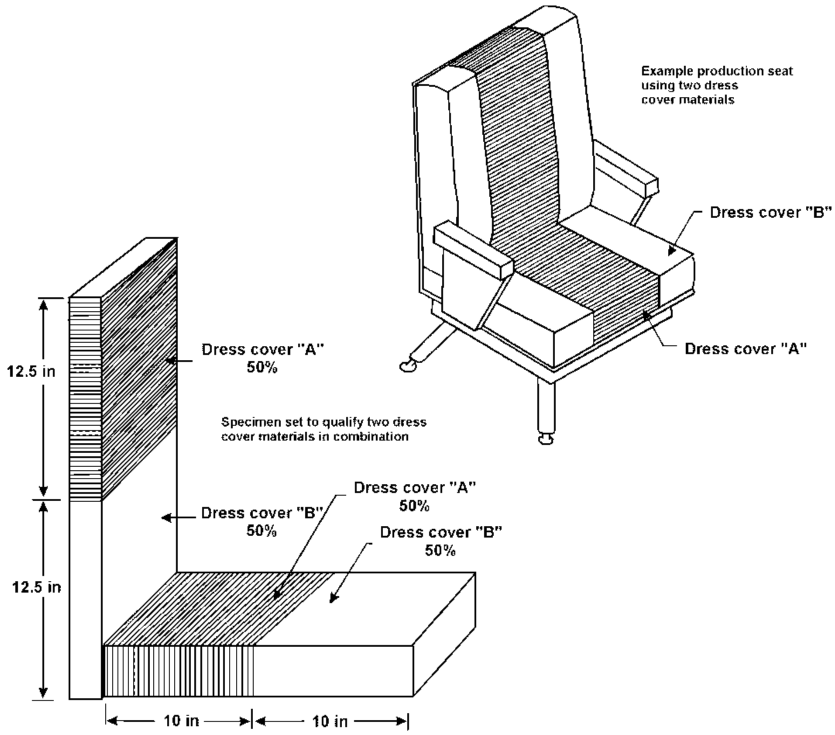


Figure D5-9. Example of production seat configuration using two dress cover materials and test specimen set to substantiate dress cover combination

D5.5 Specimen Conditioning

D5.5.1 The specimens will be conditioned at 70° ± 5°F (21° ± 2°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

D5.6 Preparation of Apparatus

D5.6.1 Level and center the frame assembly to ensure alignment of the calorimeter with the burner cone.

D5.6.2 Turn on the ventilation hood for the test chamber. Do not turn on the burner fan. Measure the airflow in the test chamber using a hot wire anemometer or equivalent measuring device. The vertical air velocity just behind the top surface of the vertical specimen will be 25 ± 10 ft/min (12.7 ± 5.1 cm/sec). The horizontal air velocity will be less than 10 ft/min (5.1 cm/sec) just above the center of the horizontal seat cushion specimen.

NOTE: The language of paragraph D5.6.2 can be met by measuring the vertical airflow at four points. These points are located behind the vertical specimen, 0.5 inch (113 mm) from the rear-facing vertical surface, 2 inches (305 mm) below the vertical specimen top surface, 2 inches (305 mm) above the vertical specimen bottom surface, and horizontally positioned 6 inches (152 mm) from each side. The measurements do not need to be made simultaneously, precluding the need for multiple anemometers. However, these measurements should be made in the same calibration cycle. The horizontal air velocity can be measured 0.5 inch (13 mm) above the geometric center of the upper-horizontal surface.

D5.6.3 The fuel flow rate will be 2.0 ± 0.1 gal/hr (0.126 ± 0.0063 L/min).

NOTE 1: If this measurement method is used to determine the fuel flow rate, the person(s) performing the measurement should realize that flammable vapors should be present in the test chamber. Caution must be exercised during the measurement period to avoid all possible ignition dangers.

NOTE 2: If a calibrated flow meter is not available, measure the fuel flow rate using a 300-500 millimeter graduated cylinder or beaker, a 0.5-inch (13 mm) or large diameter rubber or plastic drain tube, and a timer.

NOTE 3: There are two items that need consideration because they can affect the measurement accuracy. First, if a tube of insufficient diameter is used, conduit flow in the tube should add an additional back pressure to the nozzle flow. Second, when reading the collection vessel to determine the fuel volume delivered by the nozzle, ensure that the vessel is level and the fluid level is measured by reading the height of the meniscus. If either of these items is not considered, grave errors in fuel flow measurement can result.

NOTE 4: The directions for finding the fuel flow rate follow. Remove the oil burner draft tube. Place the drain tube over the nozzle orifice. Drape the tube into the collection vessel, which is at a level lower than the nozzle. Ensure that the ignitor system is turned off, then turn on the fuel pump and burner motor. Collect the fuel in the graduated cylinder or beaker for a 2-minute period. Measure the fuel volume delivered, and calculate the fuel flow rate.

2 gal/hr = 126 milliliters/minute

D5.6.4 The air inlet of the oil burner must be completely sealed, except for an opening where the air-monitoring device will be mounted. With the anemometer set up for measuring, turn the motor on, and run it for at least 30 seconds to allow the blower to reach its operating speed (it is not necessary for the ignitor and fuel flow to be turned on). Set the airflow to 67 ± 4 ft^3/min (1.89 ± 0.11 m^3/min) by adjusting the air shutter. (See paragraph D5.3.2). Once this airflow value is maintained, keep the air shutter in position by tightening the lock screw. This will be the initial airflow setting. Later adjustments, within the specified airflow range, may be necessary to attain the calibration temperatures and heat flux.

D5.6.5 Static Disks

Static disks were recently developed to stabilize the air before entering the combustion area. Two were designed by Park Oil Burner Manufacturing Company of Atlantic City, New Jersey. The Park Oil Burner disks are both made of steel (see figure D5-10 for details on disks). Disks 1 and 2 are made for easy assembly, only requiring the removal of the draft tube and installation of the disk. Disk 3 was developed by CEAT, the French Ministry of Defense. The disk is made of a Nomex® honeycomb material. CEAT uses two honeycomb disks positioned behind the stabilizer.

These disks are an optional feature and are used (any one or more of the three) to help produce a more full and even flame pattern. However, there is no guarantee of achieving calibration using a disk with all of the various makes and models of burners used throughout the industry.

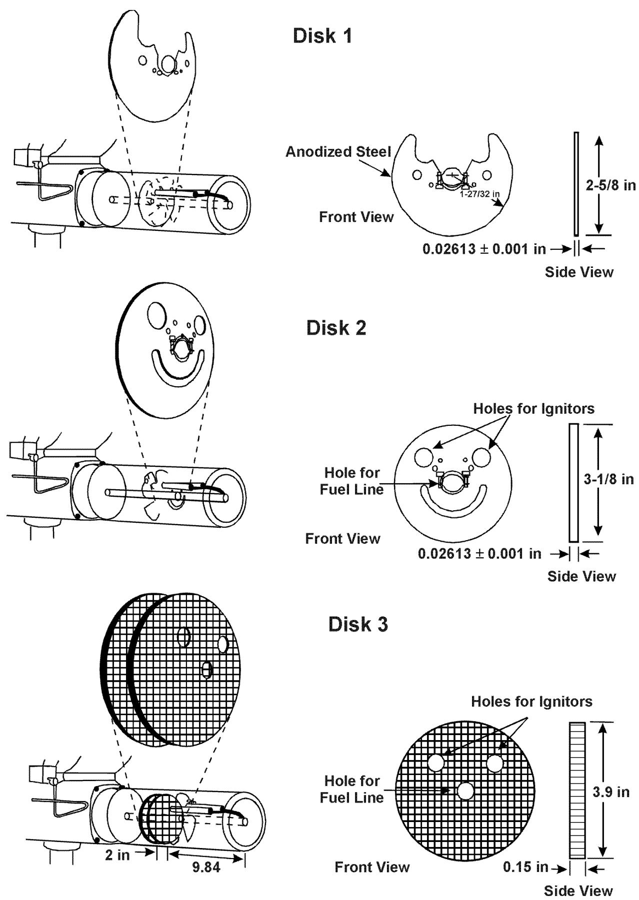


Figure D5-10. Static disk illustration

Recommendations for achieving calibration temperatures:

1. Set the stabilizer 3.25 ± 0.25 inches from the end of the draft tube.
2. Rotate the ignitor to the 6 o'clock and 9 o'clock position (viewpoint: looking toward the stabilizer from the end of the draft tube).
3. Seal all possible air leaks around the burner cone and draft tube area.

4. Use a static disk to improve flame characteristics. See figure D5-10 for information on disks.

D5.7 Calibration

D5.7.1 Secure the calorimeter in the bracket and place it on the test frame assembly used to mount specimens. Position the burner so that the vertical plane of the burner cone exit is centered in front of the test frame assembly at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the calorimeter face. Ensure that the horizontal centerline of the calorimeter is offset 1 ± 0.0625 inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone (see figure D5-5).

D5.7.1.1 Prior to starting the burner, ensure that the calorimeter face is clean of soot deposits and that there is water running through the calorimeter.

NOTE: Operating the calorimeter without water running through it could permanently damage the calorimeter.

D5.7.2 Rotate the burner from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of productions of combustion and soot.

NOTE: A stainless-steel wire brush is one possible cleaning tool. Soot buildup inside the burner cone can affect the flame characteristics and cause calibration difficulties. Because the burner cone may distort with time, dimensions will need to be checked periodically.

D5.7.3 While the burner is rotated out of the test position, turn on the fuel and light the burner. Allow it to warmup for 2 minutes. Move the burner into the test position and adjust the air intake and oil burner components to achieve a heat flux of 10 Btu/ft^2-second or greater (11.36 W/cm^2 or greater). Record heat-flux density measurements at least once per second, averaged over a 30-second time period, to ensure a steady-state condition.

D5.7.4 Replace the calorimeter bracket with the thermocouple rake, ensuring that the distance of each of the seven thermocouples is 4 ± 0.125 inches (102 ± 3 mm) from the vertical plane and offset 1 ± 0.0625 inches (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone exit (see figure D5-6).

D5.7.5 Start the burner and allow it to warm up for 2 minutes. After warmup, move the burner into position and record the temperature of each thermocouple at least once every second averaged over a 30-second time period. Of the seven thermocouples used, any two will be equal to or greater than 1750°F (954°C), whereas the remaining thermocouples will each be equal to or greater than 1800°F (982°C). The average of the seven thermocouples must be equal to or greater than 1800°F. After a steady-state condition has been achieved with the required temperatures previously mentioned, turn off the burner.

NOTE: It is advisable to run within reasonable bounds of the heat flux and temperature requirements in sections D5.7.3 and D5.7.5. If the heat flux and temperature are significantly higher, erratic data may occur.

D5.7.6 If the temperature of each thermocouple is not within the specified range, repeat sections D5.7.1 through D5.7.5 until all parameters are within the calibration.

D5.7.7 When calibration is attained, tighten the air shutter's lock screw.

NOTE: Calibrate the burner prior to each test until consistency has been demonstrated. After consistency has been confirmed, several tests can be conducted with calibration before and after each series of tests.

D5.8 Test Procedure

D5.8.1 Record the weight of each set of seat bottom and seat back cushion specimens to the nearest 0.02 pound (9 g), and secure the test specimens to their respective frames. The seat back cushion can be secured at the top with wires. Reference paragraph D5.3.5 of the Chapter D5 Supplement for guidance information.

D5.8.2 Ensure that the vertical plane of the burner cone is at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the test specimen and that the horizontal centerline of the burner cone is centered with the bottom cushion, as shown in figure D5-2.

D5.8.3 When ready to begin the test, direct the burner away from the test position to the warmup position so that the flame will not impinge on the specimen. Turn on and light the burner, and allow it to stabilize for 2 minutes.

D5.8.4 To begin the test, rotate the burner into the test position and start the timing device when the burner is in the final position.

D5.8.5 Expose the test specimen to the burner flame for 2 minutes, and then turn off the burner. Immediately rotate the burner out of the test position.

D5.8.6 Terminate the test when the specimens self-extinguish. If the specimens do not self-extinguish after 5 minutes from the time the burner has been turned off, terminate the test by extinguishing the test specimens.

D5.8.7 Immediately after test termination, determine the posttest weight of the remains of the seat cushion specimen set to the nearest 0.02 pound (9 g), excluding droppings.

D5.8.8 Measure the four burn lengths. Reference paragraph D5.8.8 of the Chapter D5 Supplement for help in determining burn length.

NOTE: An industry practice acceptable to the FAA for determining specimen damage length, to measure burn length, has been to use an object with a dull point, such as a pencil, and to scrape the dress covering. If the object penetrates the dress covering, damage has occurred because of that area's combustion. If the dress covering is not penetrated, damage has occurred because of pyrolysis and is not considered damaged by combustion.

D5.9 Report

D5.9.1 Identify and describe the specimen being tested. Report the type of foam: flame retardant ([FR] molded or cut); foam density, if known; and manufacturer and type of FR treatment, if known.

D5.9.2 Report the number of specimen sets tested.

D5.9.3 Report the pretest and posttest weight of each set, the calculated percentage weight loss of each set, and the calculated average percentage weight for the total number of sets tested.

D5.9.4 Report each of the four burn lengths for each set tested.

D5.10 Requirements

D5.10.1 For each of the burn lengths measured, the burn length may not exceed 17 inches (43.2 cm) on at least two-thirds of the total number of specimen sets tested. Additionally, the average burn length for each of the measured lengths will not exceed 17 inches.

D5.10.2 The average percentage weight loss will not exceed 10 percent.

D5.10.3 The weight loss of at least two-thirds of the total number of specimen sets tested will not exceed 10 percent.

Chapter D6
Oil Burner Test for Cargo Liners

D6.1 Scope

D6.1.1 This test method evaluates the flame penetration resistance capabilities of aircraft cargo compartment lining materials using a high-intensity open flame to show compliance to the requirements of 14 CFR 25.855 at amendment 25-138 and earlier.

D6.2 Definitions

D6.2.1 Burnthrough

Burnthrough is defined as flame penetration of the test sample or the development of a visible breach, opening, gap, fissure, or any void through which a flame penetrates during the test. The development of any such void that allows flame passage during the test period shall be cause for failure.

D6.2.2 Sample Set

A sample set consists of three or more replicates of a ceiling and sidewall cargo liner panel installation.

D6.3 Apparatus

D6.3.1 Test-Sample Frame

The test-sample frame is shown in figures D6-1 and D6-2.

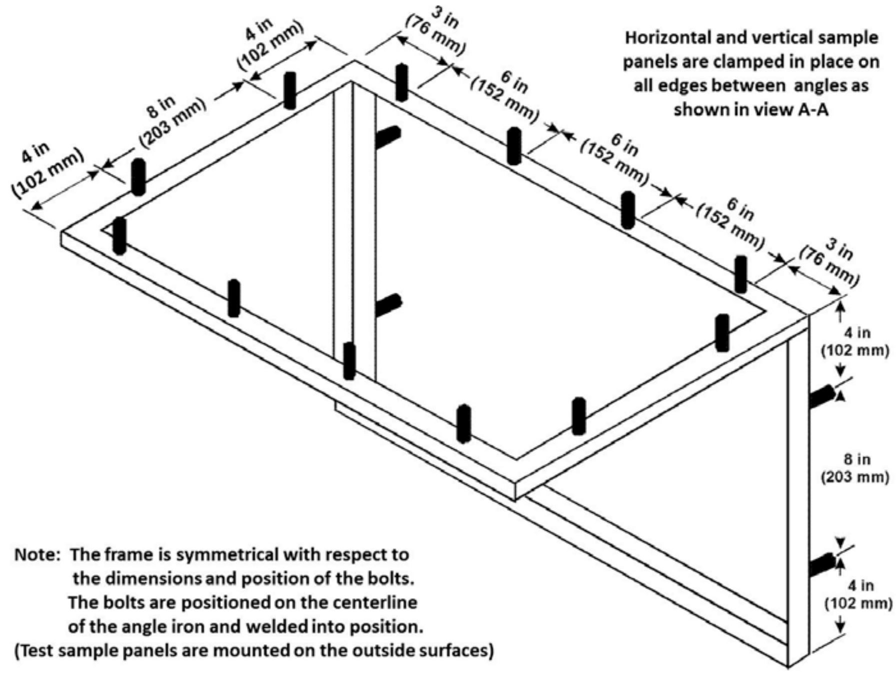


Figure D6-1. Cargo liner test-sample frame

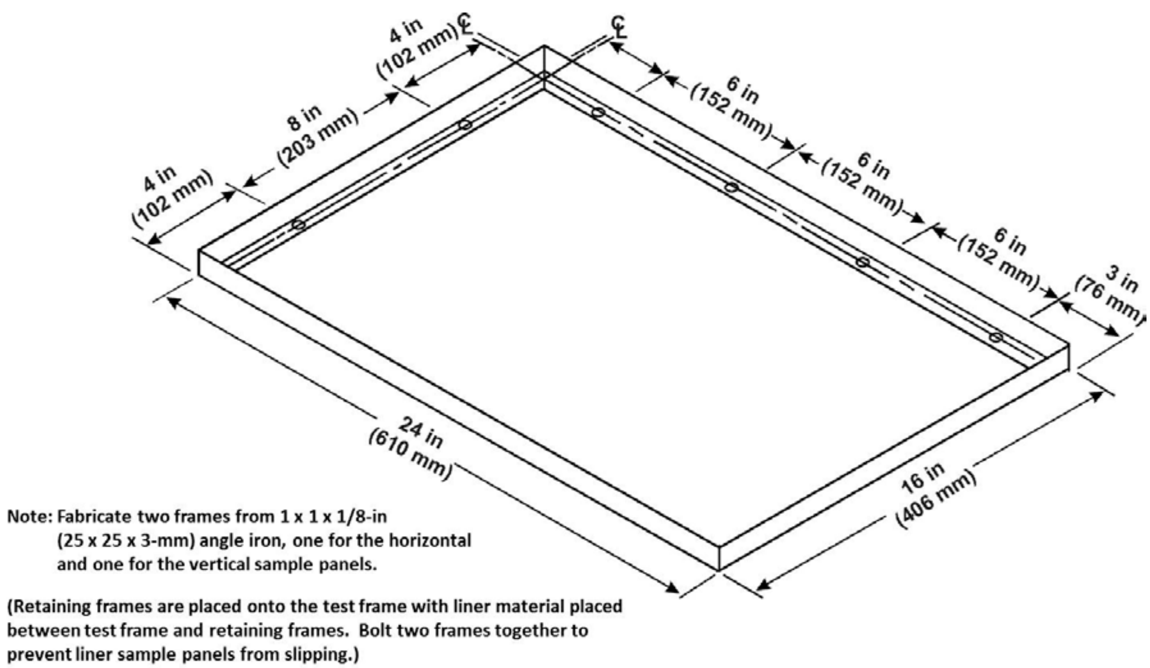


Figure D6-2. Cargo liner test-sample panel retaining frame

D6.3.2 Test Burner

The burner should be mounted on a swiveling device capable of allowing it to be directed away from the test sample during warmup, as shown in figure D6-3. The burner will be a modified gun type, such as Park Model DPL 3400™, Lennox® Model OB-32, or Carlin Model 200 CRD™. Flame characteristics can be enhanced by the optional use of a static disk or tabs. Major deviations, such as a different burner type, should have thorough comparison testing. Temperature, heat-flux measurements, and test results must correspond to those produced by an FAA-approved burner.

NOTE 1: The basic burner and the use of tabs are described in FAA Powerplant Engineering Report No. 3A, "Standard Fire Test Apparatus and Procedure for Flexible Hose Assemblies," dated March 1978, and Report No. DOT/FAA/RD/76/213, "Re-evaluation of Burner Characteristics for Fire Resistant Tests," dated January 1977. The test settings specified in this specification, however, differ from those specified in the above reports.

NOTE 2: If a NexGen sonic-type burner is to be used, see the Chapter D6 Supplement for all test burner information.

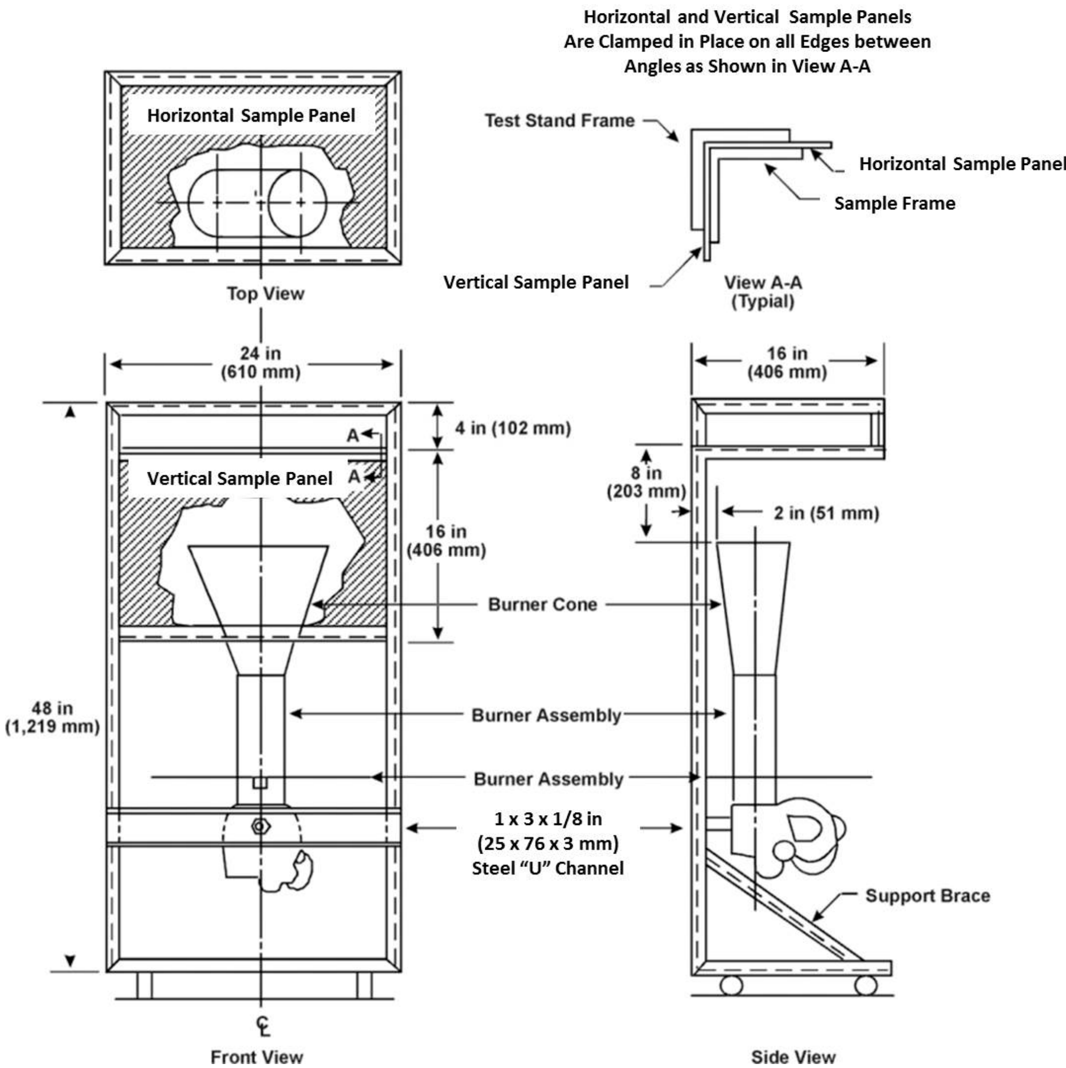


Figure D6-3. Test apparatus for horizontal and vertical mounting for cargo liner oil burner testing

D6.3.2.1 Nozzle

A nozzle will be provided to maintain the fuel pressure to yield a nominal 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min) fuel flow.

NOTE: A Monarch 80-degree AR or 80-degree R nozzle, nominally rated at 2.25 gal/hr (0.142 L/min) at 100 lb/in^2 (0.69 MPa) and operated at 85 lb/in^2 (0.59 MPa) gauge, has been found satisfactory to maintain a fuel flow of 2 gal/hr (0.126 L/min) and produce a proper spray pattern. A Monarch 80-degree CC nozzle, nominally rated at 2 gal/hr at 100 lb/in^2 and operated between 95 and 105 lb/in^2 gauge, is also acceptable. Minor deviations to the fuel-nozzle spray angle, fuel pressure, or other parameters of the nozzle are acceptable if the fuel-flow rate, flame temperature, and burner heat-flux density conform to the requirements of section D6.6 of this handbook.

D6.3.2.2 Burner Cone

A 12 ± 0.125-inch (305 ± 3-mm) burner cone will be installed at the end of the draft tube. The cone will be made of stainless steel or a similar type of noncorrosive high-temperature metal and will have a thickness of 0.065 ± 0.015 inch (1.65 ± 0.381 mm). The opening of the cone will be 6 ± 0.25 inches (152 ± 6 mm) high and 11 ± 0.25inches (280 ± 6 mm) wide (see figures D6-4a and D6-4b).

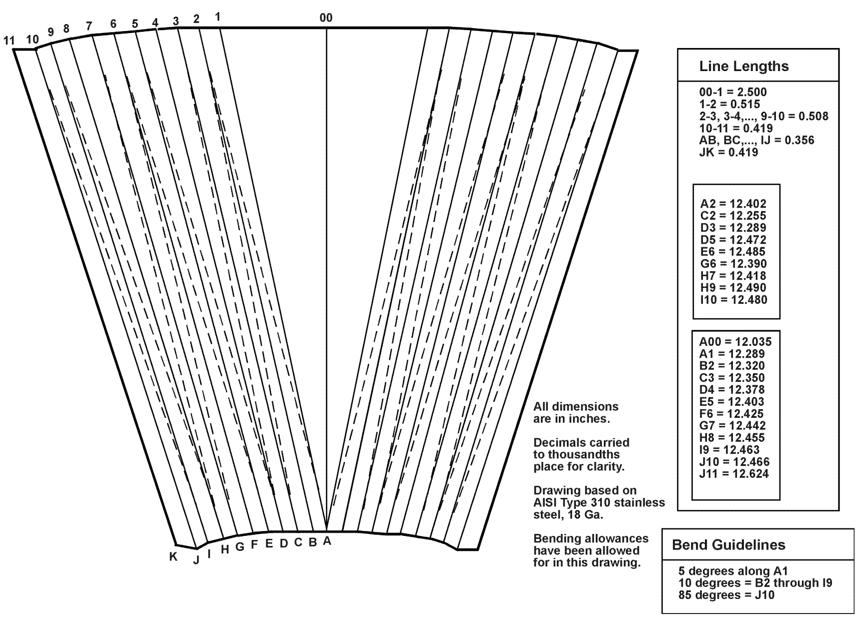


Figure D6-4a. Burner cone layout and bending pattern

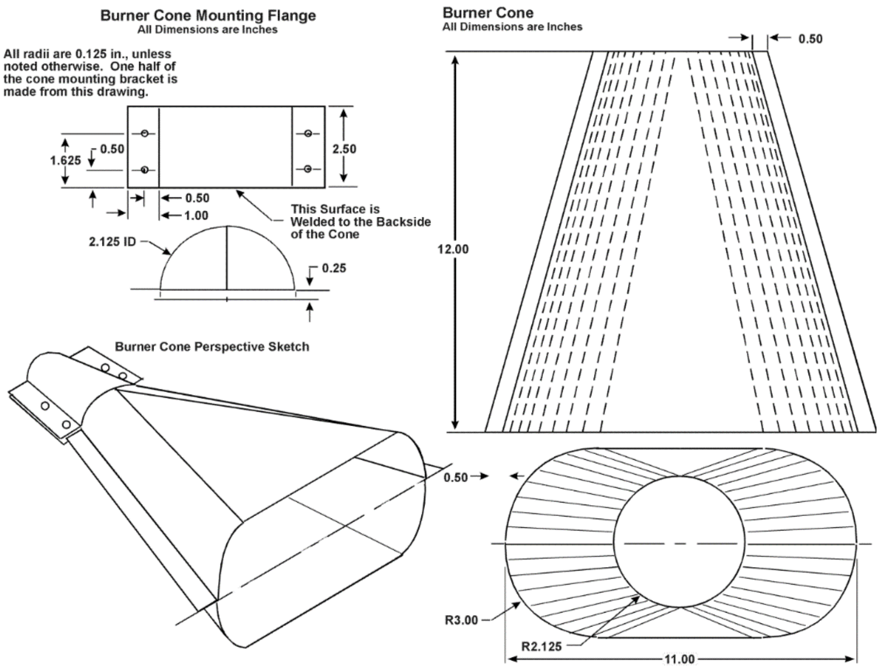


Figure D6-4b. Burner cone details

D6.3.2.3 Fuel-Pressure Regulator

A fuel-pressure regulator, adjusted to deliver 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min), will be provided.

NOTE: A fuel-pressure regulator that is adjusted to deliver a 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min) flow through the nozzle should be provided. An operating fuel pressure of 85 ± 4 psig (0.59 ± 0.02 MPa) for a 2.25 gal/hr (0.142 L/min) 80-degree spray angle nozzle has been found satisfactory.

D6.3.2.4 Fuel

Either number 2 grade kerosene or ASTM D2 fuel (number 2 grade fuel oil) will be used.

NOTE: Number 2 diesel fuel, Jet A, or the international equivalent is the recommended fuel because it has been found to produce satisfactory results if the flow rate and inlet airflow conform to the requirements of sections D6.6 and D6.7 of this handbook.

D6.3.2.5 Burner Airflow

Adjust the shutter to attain an airflow of 67 ± 4 ft^3/min (1.89 ± 0.11 m^3/min). See section D6.6.1 of this chapter.

D6.3.3 Calorimeter

The calorimeter will be a total heat-flux density, foil-type Gardon gauge of an appropriate range, such as 0-15 BTU/ft^2-sec (0-17 W/cm^2), accurate to ± 3% of the indicated reading.

D6.3.3.1 Calorimeter Mounting

The calorimeter will be mounted in a 6 by 12 ± 0.125-inch (152 by 305 ± 3-mm) by 0.75-inch-thick (19-mm) insulating block that is attached to a steel angle bracket for placement in the test stand during burner calibration (see figure D6-5). The insulating block will be monitored for deterioration and the mounting shimmed as necessary to ensure that the calorimeter face is parallel to the exit plane of the test burner cone.

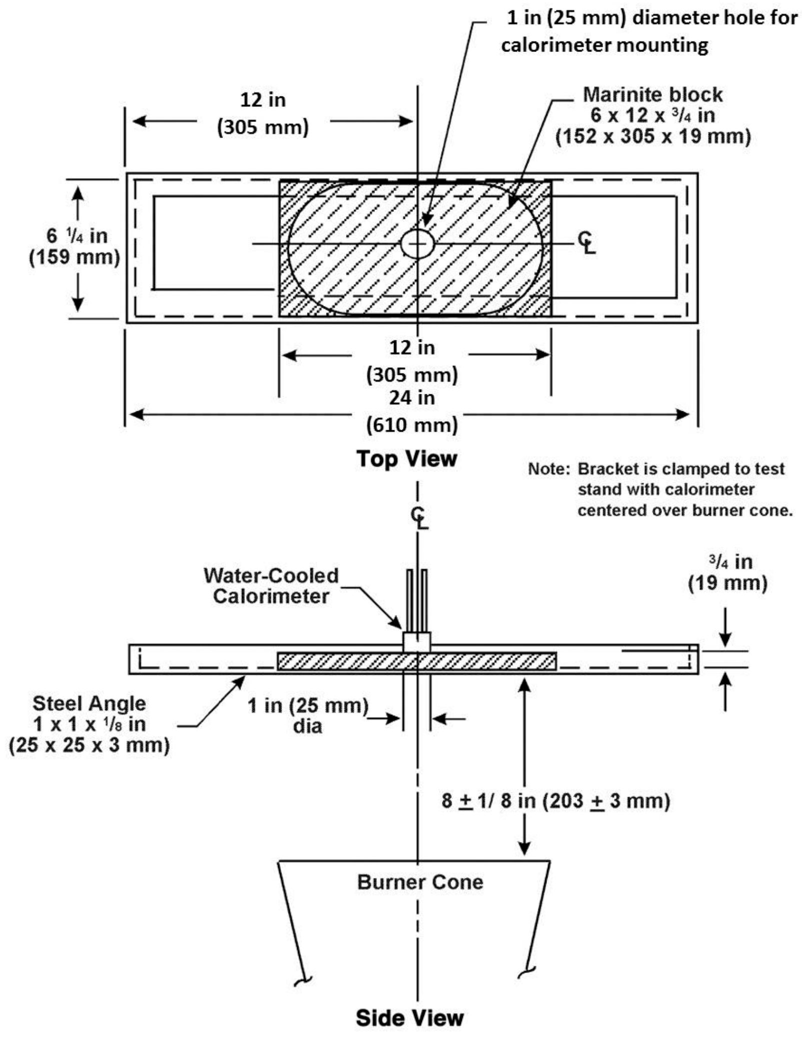


Figure D6-5. Top and side views of calorimeter bracket

D6.3.4 Thermocouples

The seven thermocouples to be used for calibration will be 0.0625-inch (1.6-mm) ceramic-packed, metal-sheathed, type K (chromel-alumel), grounded junction thermocouples with a nominal 30 AWG-size conductor. The seven thermocouples must be attached to a steel angle bracket to form a thermocouple rake for placement in the test stand during burner calibration, as shown in figure D6-6.

NOTE: The thermocouples are subjected to high temperature durations during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases, extreme variations in temperature, or no temperature reading at all are signs that the thermocouple or thermocouples are degrading or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

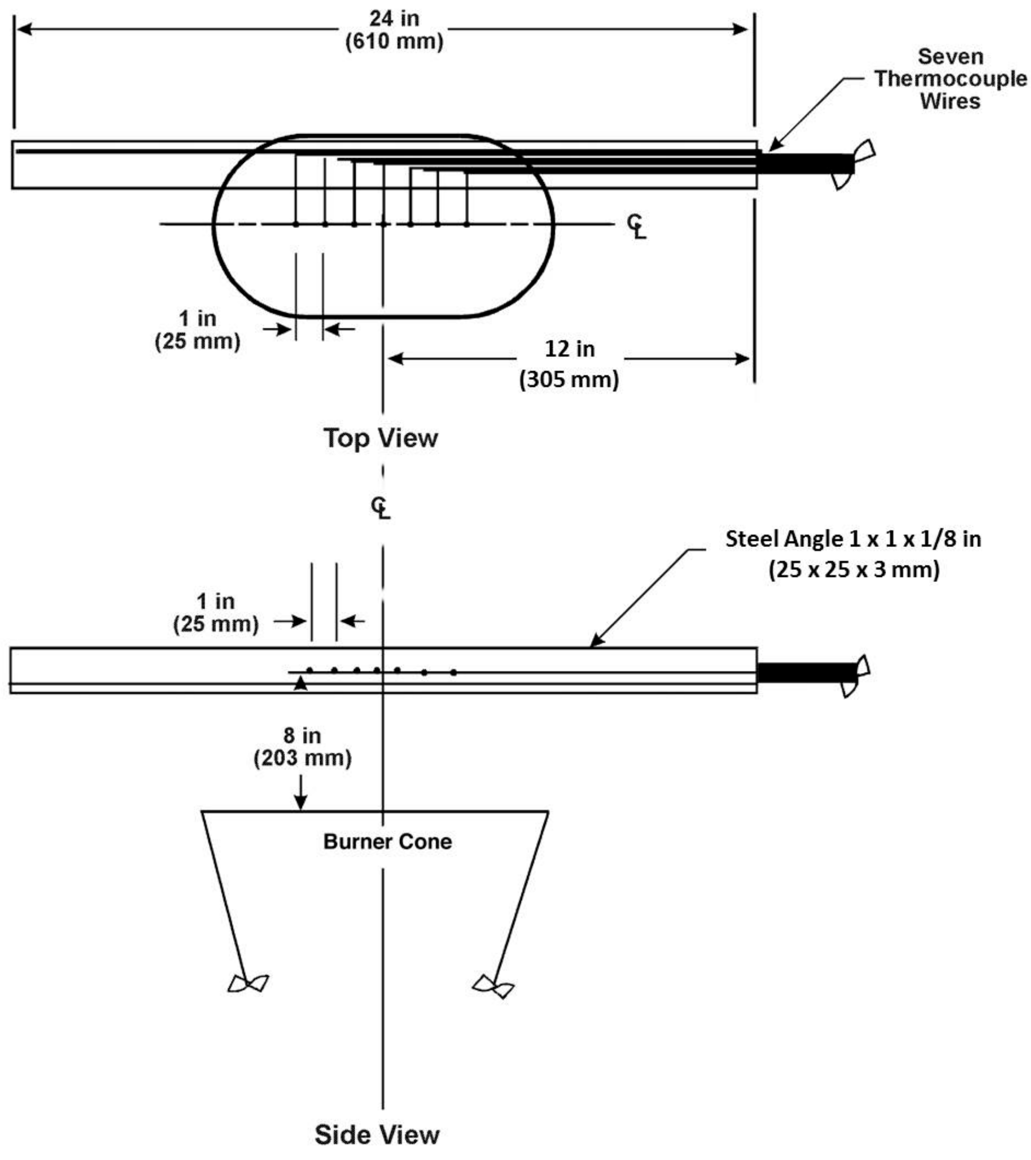


Figure D6-6. Top and side view of thermocouple rake bracket

D6.3.5 Sample Backside Temperature Thermocouple

A thermocouple will be used to monitor the temperature above the ceiling (horizontal) panel during cargo liner sample testing. The thermocouple must be 0.0625-inch (1.6-mm) in diameter, ceramic packed, 310 stainless-steel sheathed, type K (chromel-alumel), and have a grounded junction with a nominal 30 AWG-size conductor. The thermocouple tip should be a minimum of 2 inches (51 mm) away from any hardware used to mount the thermocouple in the test position.

D6.3.6 Instrumentation and Equipment

D6.3.6.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range will be provided to measure and record the outputs of the calorimeter/thermocouples.

D6.3.6.2 Timing Device

A stopwatch or other device accurate to within ± 1 second per 8 hours (± 3 sec/day) will be provided to measure the time of application of the burner flame, the material flaming time, and the burnthrough time.

D6.3.6.3 Intake Air Anemometer

A vane-type air-velocity sensing unit will be used to monitor the flow of air at the intake of the oil burner. The intake will be completely sealed except for an opening for the air-velocity sensor where the intake will be centered and mounted. See the anemometer setup in figure D6-7.

NOTE: The Omega® microprocessor-based portable air-velocity kit, model HH-30, is a recommended unit. The kit includes a vane-type air-velocity sensor, a handheld digital readout displaying air velocity, extension rods, and a 9-volt lithium battery. Because the unit monitors air velocity in FPM or MPS ± 1% reading accuracy, necessary conversions must be made to attain airflow values. To do this, the area of the opening of the air sensor must be measured. Once the area is found, install the air-velocity sensor at the oil burner inlet (see figure D6-7 for location). Following the procedures prescribed in section D6.6.1, this value should be multiplied by the air-velocity reading. (The area of the air velocity sensor for the Omega model HH-30 is 0.037 ft^2 [0.0034 m^2]. As an example, by maintaining an air-velocity reading of 1800 ft/min using the Omega air sensor described above, an airflow of 67 ft^3/min should be achieved). If an air-velocity sensor other than the Omega model HH-30 is being used, the same conversions apply.

$$\text{Airflow} = \text{Air Velocity} \times \text{Area of Opening (Air Velocity Sensor)}$$

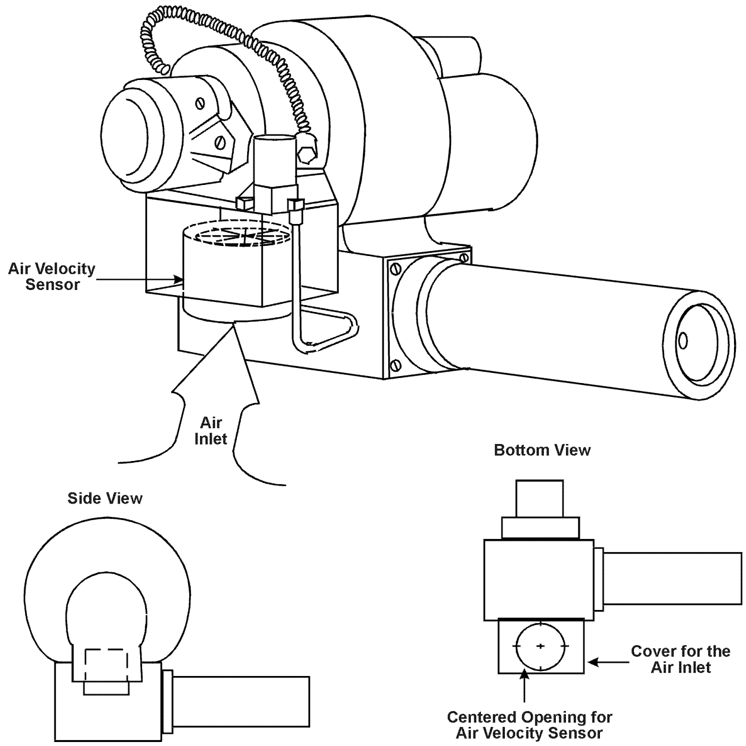


Figure D6-7. Illustration for the location of the air-velocity sensor

D6.3.6.4 Test-Chamber Anemometer

A handheld vane-type or hotwire-type air velocity sensing unit capable of measuring accurately in the 0–100 ft/min range must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating.

D6.3.6.5 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. The test chamber must have a minimum floor area of 10 feet by 10 feet (305 by 305 cm).

D6.3.6.6 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

D6.4 Test Samples(s)

D6.4.1 Sample Configuration

Each cargo liner panel type and design configuration will be tested. Design configuration includes cargo compartment design features such as corners, joints, seams, lamp assemblies, pressure relief valves, and temperature sensors that may affect the capability of a cargo compartment to safely contain a fire (see section D6.8.9).

D6.4.1.1 Ceiling and sidewall liner panels may be tested individually if a baffle of fire-resistant material, such as Superwool or Marinite, is used to simulate the missing panel.

D6.4.2 Sample Number

A minimum of three samples or a sample set for each panel type or design configuration will be prepared for testing.

D6.4.3 Sample Panel Size

The sample panels to be tested will measure 16 ± 0.125 inches (406 ± 3 mm) by 24 ± 0.125 inches (610 ± 3 mm).

D6.5 Sample Conditioning

D6.5.1 The samples will be conditioned at 70° ± 5°F (21° ± 2°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

D6.6 Preparation of Apparatus

D6.6.1 The air intake of the oil burner must be completely sealed, except for an opening where the air-monitoring device will be placed. With the anemometer set up for measuring, turn the motor on and run it for at least 30 seconds to allow the blower to reach its operating speed (it is not necessary for the ignitor and fuel flow to be turned on). Set the airflow to 67 ± 4 ft^3/min (1.89 ± 0.11 m^3/min) by adjusting the air shutter (see paragraph D6.3.5.2 for airflow conversion). Once this airflow value is attained, keep the air shutter in position by tightening the lock screw. This will be the initial airflow setting. Later adjustments may be necessary to reach calibration temperatures and heat flux within the specified airflow range.

NOTE 1: An alternate method of airflow measurement involves removing the burner extension from the end of the draft tube. Turn on the blower portion of the burner without turning on the fuel or igniters. Measure the air velocity using a hotwire anemometer. Adjust the airflow using the damper so that the airflow is in the range of 1550–1800 ft/min (787 to 914 cm/sec). (If tabs are being used, the tabs should be removed prior to measuring the airflow. After the measurement is complete, reinstall the tabs and the cone extension).

NOTE 2: If a NexGen Sonic-type burner is to be used, see the Chapter D6 Supplement for all test burner information.

D6.6.2 If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon tubing and appropriately sized graduated cylinder. Slip the Tygon tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon tubing into a small bucket or other collection basin. Turn on the fuel pump and the burner motor, making sure the igniter system is off. After establishing a steady stream of fuel flow[1],

[1] When collecting fuel, it is important to establish a steady stream of fuel before starting the measurement process. A 10-second period is recommended.

simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Collect the fuel for a 2-minute period, making certain to immediately direct the tubing exit away from the graduated cylinder at precisely 2 minutes. Calculate the flow rate and ensure that it is 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min). If the flow rate is not within the tolerance, adjust the fuel pressure accordingly.

D6.6.3 Level the sample holder frame assembly to ensure proper alignment with the burner cone. With the sample test frame in the test position above the burner cone, check for proper alignment (i.e., distance from exit of burner cone to face of test sample, proper sample position with respect to cone centerline). The movable burner or sample frame should incorporate mechanical stops or detents to ensure correct positioning without measurement during testing.

D6.6.4 Turn on the ventilation hood for the test chamber. Do not turn on the burner blower motor. Measure the airflow in the test chamber using a handheld vane-type anemometer or equivalent measuring device. The vertical air velocity within a 12-inch (30.5 cm) radius from any point on the horizontally positioned sample must be less than 100 ft/min (50.8 cm/sec). The horizontal air velocity within a 12-inch (30.5 cm) radius from any point on the sample must be less than 50 ft/min (25.4 cm/sec).

D6.6.5 The temperature of the test chamber should be between 50°F and 100°F (10°C and 38°C) before the start of each test. The chamber air temperature should be measured at the same height as the center of the test sample, within 12 inches (30.5 cm) laterally.

D6.7 Calibration

D6.7.1 Secure the calorimeter in its bracket and place it on the sample mounting test frame, making sure it is centered over the burner cone at a distance of 8 ± 0.125 inches (203 ± 3 mm) from the exit of the burner cone, as shown in figure D6-5. Ensure that the burner is in the proper position relative to the sample mounting frame, 2 ± 0.125 inches (51 ± 3 mm) from the sidewall panel frame. Position the center of the calorimeter over the center of the burner cone.

D6.7.2 Prior to starting the burner, ensure that the calorimeter face is free of soot deposits and that there is water running through the calorimeter.

CAUTION! Exposing the calorimeter to the burner flame without water running through it will destroy the calorimeter.

D6.7.3 Rotate the burner from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of productions of combustion and soot.

NOTE: A stainless-steel wire brush is one possible cleaning tool. Soot buildup inside the burner cone can affect the flame characteristics and cause calibration difficulties. Because the burner cone may distort with time, dimensions will need to be checked periodically.

D6.7.4 While the burner is in warmup position, turn on the fuel flow and light the burner. Allow it to warm up for at least 2 minutes. Move the burner into test position and adjust the air intake to produce a heat flux of 7.5 BTU/(ft^{2}sec) (8.6 W/cm^2) or greater. Record the heat-flux measurements at least once per second, averaged over a 30-second time period, to ensure that steady-state conditions have been achieved. After steady-state conditions have been achieved, turn the burner off.

NOTE: The airflow should be adjusted to produce the proper flame and the proper temperature and heat-flux density. Two different flame profiles may yield the same temperature and heat-flux density. The correct flame is generally 8–10 inches in length and orange-yellow in color.

D6.7.5 Replace the calorimeter bracket with the thermocouple rake. Check the distance of each of the seven thermocouples to ensure that they are located 8 ± 0.125 inches (203 ± 3 mm) from the horizontal plane of the burner exit. Place the center thermocouple (thermocouple number 4) over the center of the burner cone exit (see figure D6-6).

D6.7.6 Turn on the burner and allow it to warm up for at least 2 minutes. After warmup, record the temperature of the thermocouples at least once per second averaged over a 30-second time period. The temperature of each thermocouple will be 1600°F (871°C) or greater.

D6.7.7 If the temperature of each thermocouple is not within the specified range, repeat sections D6.7.1 through D6.7.3 until all parameters are within the calibration range. When required thermocouple temperatures have been achieved, check that the airflow is within the required range. Once the parameters are within the specified range, secure the air shutter by tightening the lock screw.

NOTE: Static disks were developed to stabilize the air before entering the combustion area and are an optional feature. Disks 1 and 2 (see figure D6-8) are made for easy assembly, only requiring the removal of the draft tube and installation of the disk. Both are made of steel. Disk 3 is made of a Nomex honeycomb material. Disks 1 and 2 were designed by Park Oil Burner Manufacturing Company of Atlantic City, New Jersey. Disk 3 was developed by CEAT, the French Ministry of Defense. These disks are used in whatever combination of one or more that will produce a more full and even flame pattern. For example, CEAT uses two honeycomb disks positioned behind the stabilizer. However, given that there are various makes and models of burners used throughout the industry, there is no exact prescription for achieving calibration using a disk.

D6.7.8 Calibrate prior to each test until consistency (heat flux and temperature remaining within calibration tolerance) has been demonstrated. After consistency has been confirmed, several tests can be performed with calibration conducted before and after the tests.

NOTE 1: Following are recommendations for achieving calibration temperatures and heat flux:

1. Set the stabilizer 3.25 ± 0.25 inches from the end of the draft tube.
2. Rotate the igniter to the 6 o’clock and 9 o’clock positions (viewpoint: looking toward the stabilizer from the end of the draft tube).
3. Seal all possible air leaks around the burner cone and draft tube area.
4. Use static disk to improve flame characteristics.
5. Replace thermocouples after 50 hours of use.

NOTE 2: If a NexGen sonic-type burner is to be used, see the Chapter D6 Supplement for all test burner information.

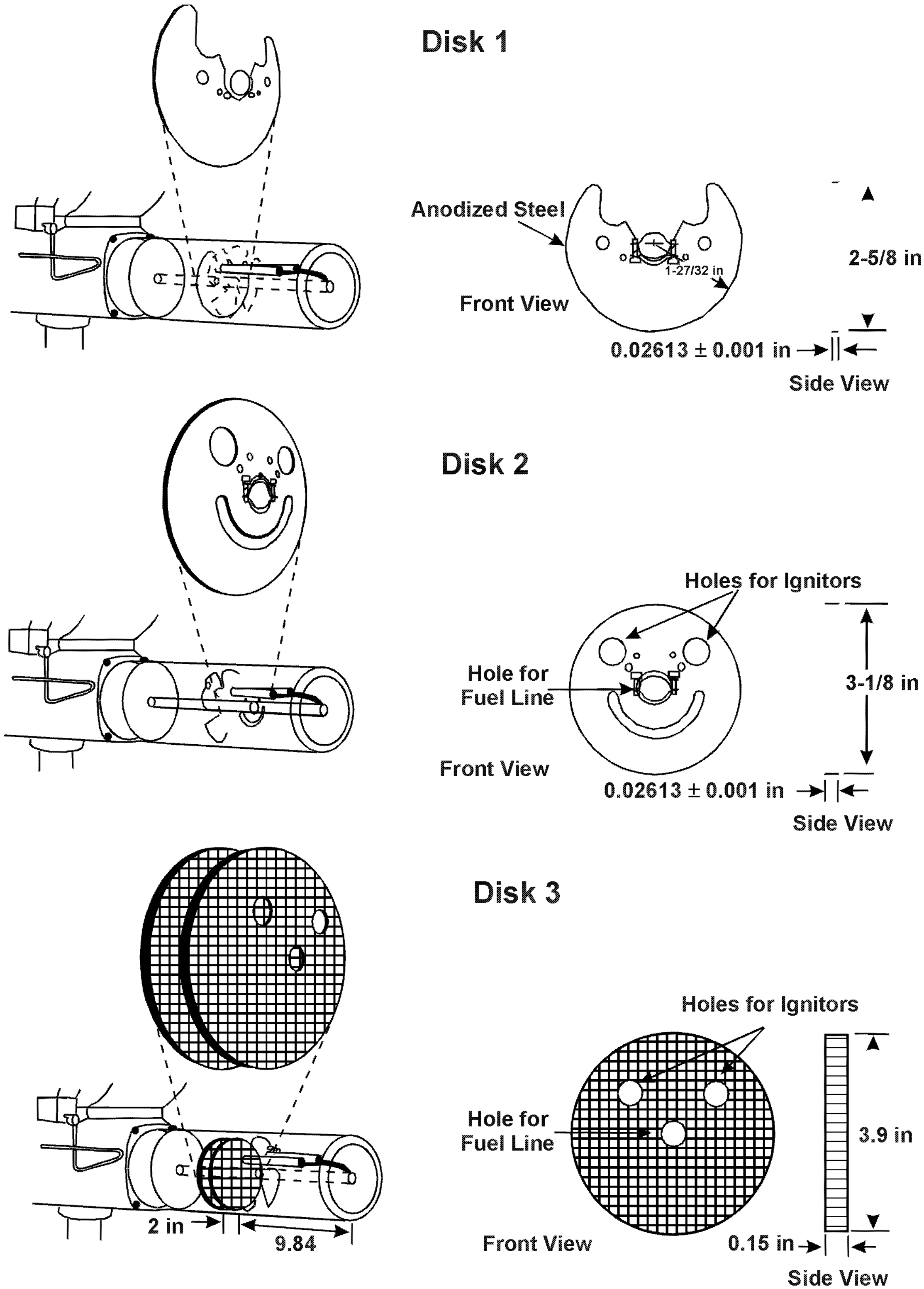


Figure D6-8. Static disk illustration

D6.8 Procedure

D6.8.1 Examine and clean the cone of soot deposits and debris.

D6.8.2 Mount the sidewall/ceiling cargo liner sample panel(s) on the respective frame(s) and secure to the test frame(s) using the retaining frame(s). Bolt the retaining frame(s) and the test frame(s) together. Verify that the horizontal test frame is level.

D6.8.3 Mount the 0.0625-inch backside temperature thermocouple or 0.0625inch thermocouple rake 4 ± 0.125 inches (102 ± 3 mm) above the top side of the horizontal ceiling sample test panel. If the thermocouple rake is being used, position the center thermocouple (thermocouple number 4) over the center of the burner cone exit.

NOTE: The 0.125-inch thermocouple rake used for the NexGen burner flame consistency validation measurement may not be used for measuring the backside temperature of the test sample. The larger diameter 1/8-inch thermocouple will not respond to changes in temperatures as quickly as a 0.0625-inch diameter thermocouple.

D6.8.4 Move the burner or sample test rig into the warmup position so that the flame does not impinge on the test sample during the warmup period. Turn on the burner, and allow it to stabilize for at least 2 minutes.

D6.8.5 Move the burner or sample test rig into the test position, and simultaneously start the timing device when the burner or sample test rig is fully in the test position.

D6.8.6 Record the temperature of the thermocouple (thermocouple number 4, if using the thermocouple rake also used for calibration) at least once a second for the duration of the test.

D6.8.7 Expose the sample to the flame for 5 minutes or until flame penetration occurs.

D6.8.8 Turn off the burner to terminate the test.

D6.8.9 The following sections present testing procedures for patch repairs, seams, joints, fastening systems, lighting fixtures, and corners.

D6.8.9.1 Patch Repairs

Reference FAA Advisory Circular 25.855-1 for details on the proper testing of patch repairs.

D6.8.9.2 Seams, Joints, Fastening Systems, Lighting Fixtures, and Corners

The barrier material used for design features, such as recessed lighting fixtures and pressure-relief valves, will be tested in the same manner as a cargo-liner sample. Seams, joints, and fasteners in the ceiling position will be tested longitudinally, extending the length of the liner and centered over the burner cone. Seams or joints used on the sidewall will be positioned longitudinally 2 inches from the top of the vertical test-sample panel as representative of the aircraft application. Apply the test procedures in sections D6.8.1

through D6.8.8 to test these design features. Refer to FAA Advisory Circular 25.855-1 for more details.

NOTE: Test procedures for cargo-liner design features are described in FAA Technical Note DOT/FAA/CT-TN88/33, dated September 1988. The sample holder must not add reinforcement to any construction that does not exist as installed in the aircraft.

D6.9 Report

D6.9.1 Report a complete description of the material(s) being tested, including the manufacturer and thickness.

D6.9.2 Report the orientation of the panels tested (i.e., ceiling and sidewall).

D6.9.3 Record any observations regarding the behavior of the test sample during flame exposure, such as delamination, resin ignition, smoke, and the time each event occurred.

D6.9.4 Report the time of occurrence of flame penetration, if applicable, for each of the three samples tested.

D6.9.5 If flame penetration does not occur, report the maximum backside temperature and time of occurrence.

D6.9.6 Provide a record of calibration.

D6.10 Requirements

D6.10.1 None of the three samples tested will burn through within the 5-minute flame exposure.

NOTE: Flames may appear on the sample backside (side of the sample facing away from the burner), resulting from the ignition of flammable smoke or gases produced from the sample when subjected to the burner flame. This does not constitute burnthrough. Burnthrough occurs only if the flame from the burner passes through the sample material. Whereas there are no specific requirements related to backside burning, more than 60 seconds of burning on the backside is indicative of a less-reliable material. However, the sample material is considered to be a failure if the 400ºF criteria are exceeded.

D6.10.2 Each of the three samples tested will not exceed 400°F (204°C) at the backside temperature monitored during flame exposure.

D6.10.3 Samples that pass in the ceiling orientation may be used as a sidewall panel without further test.

D6.10.4 For the patch-adhesion test, the patch must be intact after the 5-minute flame exposure.

Chapter D7
Radiant Heat Testing of Evacuation Slides, Ramps, and Rafts

D7.1 Scope

D7.1.1 Applicability

This method is used to show compliance to Technical Standard Order (TSO) C69A.

D7.2 Definition

D7.2.1 Time to Failure

The time to failure is the time between the first application of heat to the specimen and the first decrease in pressure below the maximum pressure attained in the test cylinder during the test.

D7.3 Test Apparatus

D7.3.1 Pressure Cylinder and Specimen Holder

The pressure cylinder will consist of a 12.375-inch-long (314-mm) aluminum cylinder with a 7-inch (178 mm) outside diameter (OD) and a 6.5 inch (165 mm) inside diameter, as shown in figures D7-1, D7-2, and D7-3.

NOTE: Figure D7-1 represents an alternative method of securing the specimen in place on the holder by using toggle clamps instead of welded hinges and adjustable stops.

D7.3.1.1 A 0.50-inch thick (13 mm) aluminum plate will be welded to one end of the cylinder and will be drilled and tapped near its upper edge for a 0.25-inch (6.4-mm) American Standard taper pipe thread to facilitate the hookup of air pressure and pressure recording equipment.

D7.3.1.2 An aluminum ring 7 inches (178 mm) in outer diameter, 5.5 inches (140 mm) in inner diameter, and 0.50 inches thick (13 mm) will be welded to the other end of the cylinder. The ring will have eight evenly spaced 10-32 bolt holes on the circle 0.3125 inches (8 mm) from the ring's inner edge (the diameter of this circle is 6.125 inches [156 mm] and adjacent bolt holes are 2.3125 inches [60 mm] apart). A 10-32 steel bolt 0.875 inches (22 mm) long will be placed into each of the holes.

D7.3.1.3 An aluminum ring, 6.75 inches (171 mm) in outer diameter, 5.5 inches (140 mm) in inner diameter, and 0.50 inch-thick (13 mm), and two neoprene rubber gaskets with similar clearance holes to fit over the bolts will provide a means for clamping and sealing the test specimen in place. Hinges and adjustable stops will be welded to the sides of the cylinder, as shown in figures D7-1, D7-2, and D7-3.

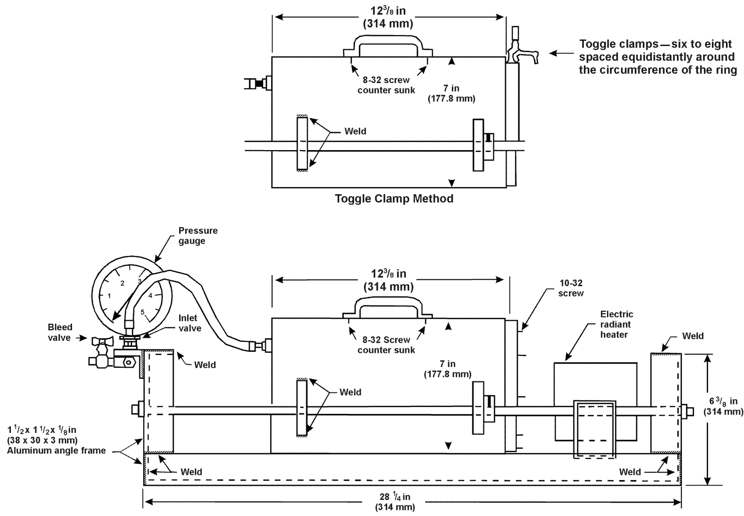


Figure D7-1. Evacuation slide material test apparatus–front view

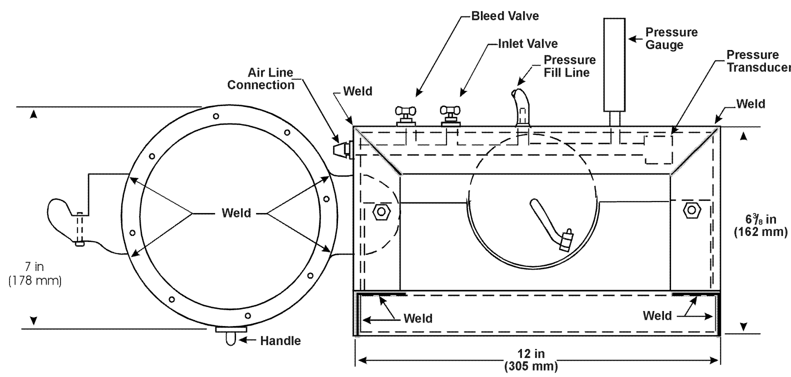


Figure D7-2. Evacuation slide material test apparatus–side view

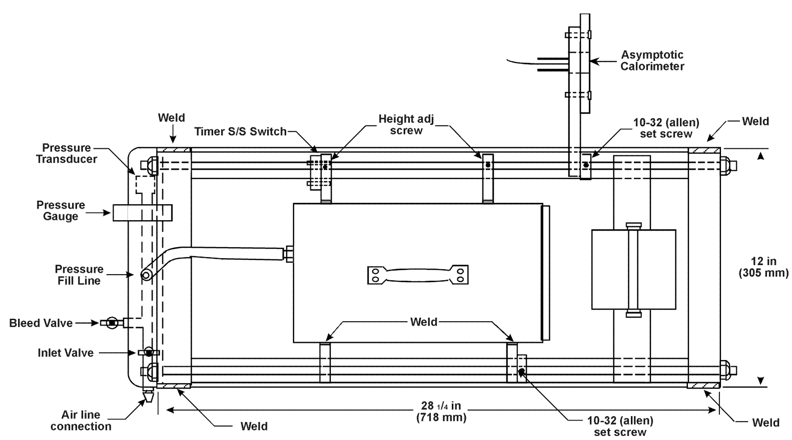
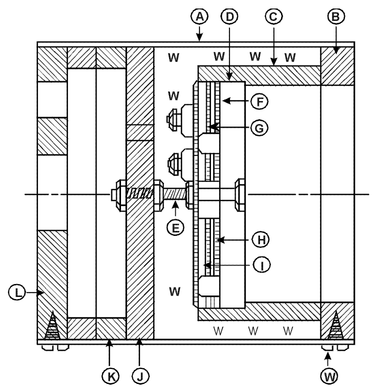


Figure D7-3. Evacuation slide material test apparatus–top view

D7.3.2 Electric Furnace

An electric furnace with a 3-inch (76-mm) diameter opening, as shown in figure D7-4, will be provided to supply a constant irradiance on the specimen surface. The smoke density chamber radiant heat furnace, or equivalent, has been found suitable.

NOTE: The electric furnace is available from Superpressure, Inc., 8030 Georgia Avenue, Silver Springs, Maryland 20910 (Catalog Number #D-257-68086).



A Stainless Steel Tube
B Ceramic Board
C Ceramic Tube
D Heating Element, 525W
E Stainless Steel Screw

F Ceramic Paper Gasket
G Stainless Steel Spacing Washers (3)
H Stainless Steel Reflector
I Stainless Steel Reflector

J Ceramic Board*
K Ceramic Board Rings*
L Ceramic Board Cover*
M Sheet Metal Screws
W Pyrex Glass Wool

* Marinite board or equivalent

Figure D7-4. Furnace details

D7.3.3 Furnace Voltage Control

A variable voltage control (115V, 600W minimum) will be provided to connect to the electric furnace power supply to adequately control the heat flux from the furnace. The furnace control system will be capable of maintaining the irradiance level under steady-state conditions for a minimum of 20 minutes.

D7.3.4 Calorimeter

A 0 to 5 Btu/ft^2-sec calorimeter will be provided to monitor the heat flux from the furnace. The calorimeter will be mounted in a 4.5-inch (114-mm) diameter by 0.75-inch-thick (19-mm) insulating block, such as calcium-silicate millboard, with the surface of the calorimeter flush with the surface of the insulating block. The calorimeter will be hinged to one of the sliding bars of the framework and centered with the furnace (see figure D7-3).

D7.3.5 Apparatus Framework

The pressure cylinder, calorimeter, and furnace are mounted on a framework, as detailed in figure D7-3. Adjustable sliding stops are located on each of the bars for setting the cylinder and calorimeter at any distance from the opening of the furnace.

D7.3.6 Pressure Supply and Equipment

Compressed air is connected to the cylinder through a needle valve attached to the end of the framework. A tee-manifold on the outlet side of the valve provides for a 0–5 psig pressure gauge, a transducer, a flexible tube to supply air to the rear plate of the pressure cylinder, and a bleed valve, as shown in figure D7-1.

D7.3.7 Instrumentation

The outputs of the calorimeter and pressure transducer are measured and recorded using a recording potentiometer or other suitable instrument capable of measurement over the range required.

D7.4 Test Specimens

D7.4.1 For each test, at least three specimens—7 inches (178 mm) in diameter with eight 0.25-inch (6-mm) holes punched in the material to match the studs in the pressure cylinder—will be cut from the material to be tested.

D7.4.2 If the pressure holding material has any exposed surfaces that are marked, overlay material, seams, or are altered in any other manner that affects radiant heat resistance, each different surface will be tested as a specimen set.

D7.5 Conditioning

D7.5.1 Condition test specimens at 70° ± 5°F (21° ± 3°C) relative humidity for a minimum of 24 hours prior to testing.

D7.6 Calibration

D7.6.1 Turn on the radiant heat furnace and other required instrumentation, and allow 30–45 minutes to stabilize heat output and for instrumentation warmup.

NOTE: To prolong the life of the furnace, increase the voltage to cold furnace slowly.

D7.6.2 Adjust the transformer to produce a radiant heat-flux density of 2 Btu/ft^2-sec (2.3 W/cm^2) when the calorimeter is positioned at approximately 1.5 inches (38 mm) in front of the radiant heat furnace.

D7.6.3 Find the precise location in front of the furnace where the test heat-flux density of 1.5 Btu/ft^2-sec (1.7 W/cm^2) is achieved by sliding the calorimeter on the horizontal bar and fixing the position with the sliding stop. Swing the calorimeter out of position.

D7.7 Procedure

D7.7.1 Conduct the tests in a draft-free room or enclosed space. It is recommended that tests be conducted under a hood or other means to remove potentially hazardous gases from the test area.

D7.7.2 Turn on the radiant heat furnace and other required instrumentation, and allow 30–45 minutes to stabilize heat output and for instrumentation warmup.

D7.7.3 Rotate the cylinder away from the furnace. Mount the specimen with the reflective surface of the material facing the furnace on the open end of the cylinder and with a neoprene gasket on each side of the specimen. Place the aluminum ring on the studs and tighten the nuts so that an airtight seal is achieved.

D7.7.4 Pressurize the cylinder to the slide material nominal operating pressure, and check for leakage.

D7.7.5 Locate the pressure cylinder so that the distance from the test specimen to the surface of the radiant heat furnace is the distance established in section D7.6.3.

D7.7.6 Place the calorimeter in front of the radiant heat furnace at the distance established in section D7.6.3, and record the heat-flux density. Verify that the heat flux is 1.5 Btu/ft^2-sec (1.7 W/cm^2). Remove the calorimeter.

D7.7.7 Rotate the pressure cylinder with the test specimen in front of the radiant heat furnace. Start the timer.

D7.7.8 Monitor the pressure cylinder from the time the specimen is placed in front of the furnace until the first observed pressure loss.

D7.7.9 Record time to failure in seconds.

D7.8 Report

D7.8.1 Report material description and full identification that may include type of fabric and coating, manufacturer, manufacturer style number, weight, thickness, color, and any alterations, if applicable.

D7.8.2 Report the test conditions, including the heat-flux density and starting pressure for each of the three specimens.

D7.8.3 Report any observations of the material behavior during the test and times of occurrence.

D7.8.4 Report the time to failure for each of the three specimens and the overall average.

D7.9 Requirement

D7.9.1 The average time to failure for the three specimens tested will be at least 90 seconds.

Chapter D8
Recommended Procedure for the Four-Ply Horizontal Flammability Test for Aircraft Blankets

D8.1 Scope

This test method is intended for use in determining the resistance of blankets to flame when tested in the horizontal position and exposed to the Bunsen burner for 12 seconds.

D8.2 Definitions

D8.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. It is 12 seconds for this test.

D8.2.2 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.

D8.2.3 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 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.

D8.3 Test Apparatus

D8.3.1 Test Cabinet

The test will be conducted in a draft-free cabinet fabricated in accordance with figures D8-1, D8-2, and D8-3, or other equivalent enclosures acceptable to the FAA. A hole may be drilled into a wall to accommodate the test fixture. 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 inches (1 mm) thick will be used for the bottom surface of the chamber.

NOTE: Because this test method employs the 45-degree test fixture, the test cabinet called out is the cabinet used for 45-degree testing. Suitable test chambers of the type described are manufactured by 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. As stated in the test method, it is permissible to use other draft-free cabinets acceptable to the FAA. One such cabinet is the

Horizontal Vertical Flame Chamber manufactured by Atlas Electric Devices (see above for address).

Draft-free implies a condition of no air currents in a closed-in space. A test cabinet other than one fabricated in accordance with figures D8-1 to D8-3 may be found to be acceptable after review by the FAA. 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 and then closing the door and observing the behavior of the smoke for signs of drafts.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing the test specimen.

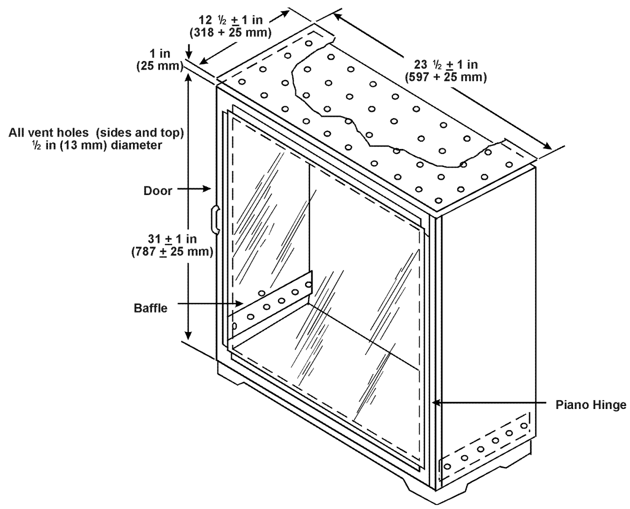


Figure D8-1. Sketch of Bunsen burner test cabinet

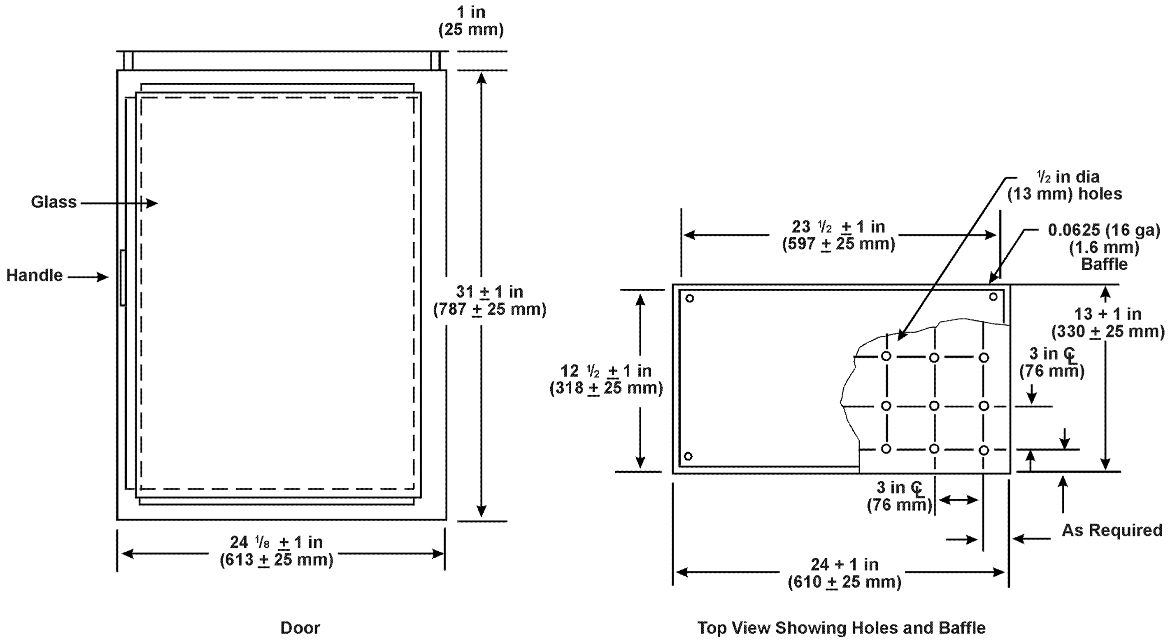


Figure D8-2. Front and top view of Bunsen burner test cabinet

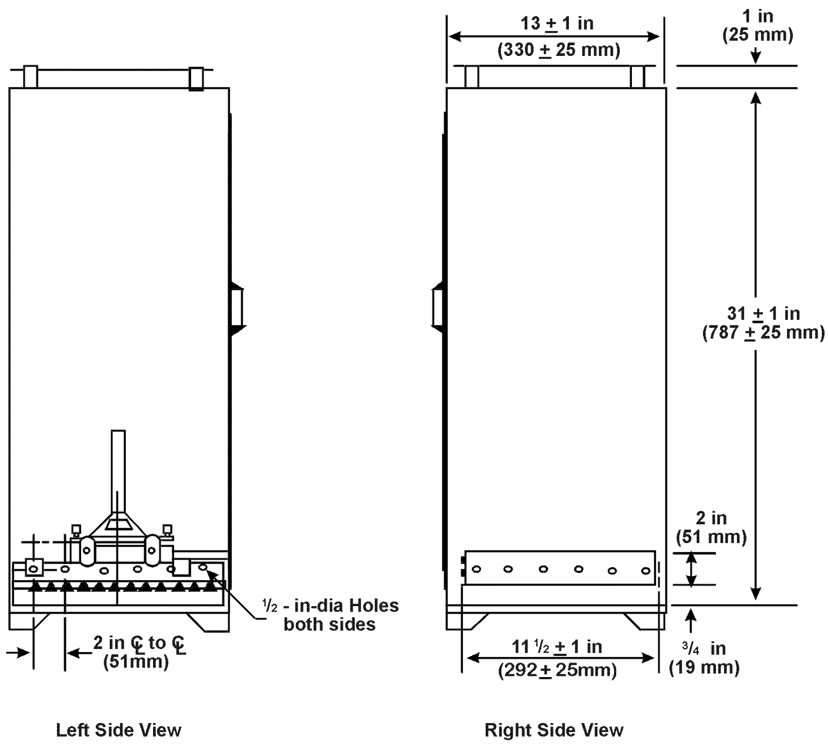


Figure D8-3. Side views of Bunsen burner test cabinet

D8.3.2 Specimen Holder

The specimen holder will be fabricated of corrosion-resistant metal, as shown in figure D8-4. This is the same holder used for the 45-degree Bunsen burner test specified in 14 CFR 25.855, with the exception of the mounting stud. Other specimen holders are acceptable if the test criteria are met.

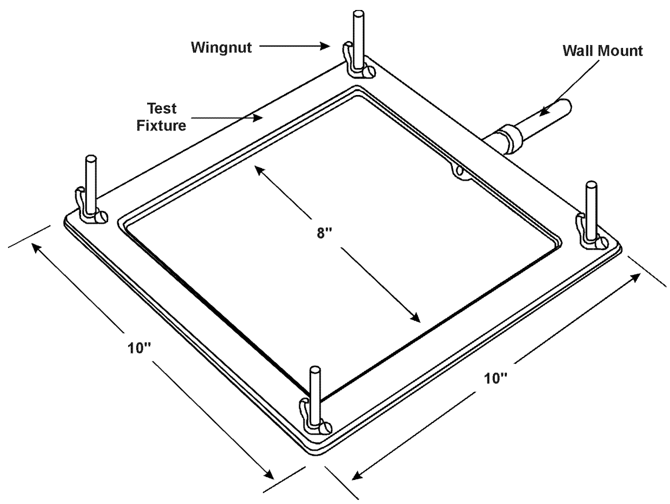


Figure D8-4. Horizontal test fixture

D8.3.3 Burner

The burner shall be a Bunsen or Tirrill type, have a 0.375-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 should be a means provided to move the burner into and out of the test position when the cabinet door is closed.

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

If the test cabinet is equipped with a glove box, it is permissible to manually move the burner into test position.

D8.3.3.1 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 flame barrel (i.e., a pure diffusion flame may be used).

NOTE: A phenomenon that some labs have experienced is a sharp decrease in flame temperature after approximately 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 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 can affect the flow rate of gas through the burner orifice. This, in turn, *can cause temperature variation. This problem can be essentially eliminated by using a two-stage regulator or adjusting pressure on a single-stage regulator as the cylinder gets low.*

D8.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing are essentially as shown in figure D8-5. A control valve system with a delivery rate designed to furnish gas to the burner under pressure of 2 1/2 ± 1/4 psi (17 ± 2 kPa) at the burner inlet should be installed between the gas supply and the burner.

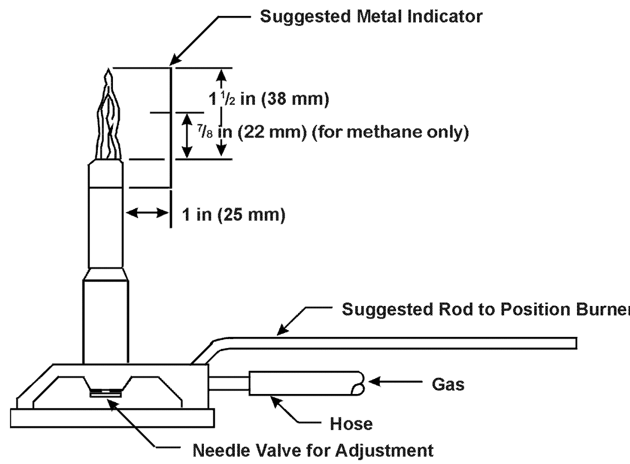


Figure D8-5. Burner plumbing and burner flame-height indicator

D8.3.3.3 Flame Height Indicator

A removable height indicator aids 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 and spaced 1 inch (25 mm) from the burner barrel, as shown in figure D8-5. 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 the proper flame profile is achieved when the height of the inner flame is 1.5 inches (38 mm) long.

NOTE: 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. However, the inner cone of the flame is 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 0.875 inches. Therefore, if the inner cone height is used to monitor flame height, the inner cone height needs to be established for that burner.

D8.3.4 Timer

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

D8.4 Test Specimens

D8.4.1 Specimen Selection

Specimens tested should be cut from new aircraft blankets. If each side of a blanket is composed of a different material, then each side must be tested.

D8.4.2 Specimen Number

At least three specimens will be prepared and tested.

D8.4.3 Specimen Size

An 8- by 8-inch specimen is the exposed sample size; however, an 11- by 11-inch specimen should be cut to pull the specimen taut once secured in the test fixture. The excess material can be trimmed off.

D8.4.4 Specimen Thickness

The specimen will be of 4-ply configuration. This may be accomplished by folding the blanket in half and then folding it again or by stacking four individual blanket specimens cut to size. This also includes blankets with decorative appliqués.

D8.5 Conditioning

D8.5.1 Condition specimens at 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before testing.

NOTE: It is recommended that only one specimen be removed at a time from the conditioning chamber prior to subjection 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 if each specimen is covered or carried in a container and protected until the specimen is subjected to the flame. Industry standard conditioning for textiles is 65 percent relative humidity and 70°F.

D8.6 Procedure

D8.6.1 Burner Adjustment

D8.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

D8.6.1.2 Open the stopcock in the gas line fully, and light the burner.

D8.6.1.3 Adjust the needle valve on the burner to give the proper 1.5-inch (38-mm) flame height, and remove the flame-height indicator.

D8.6.2 Test Procedure

D8.6.2.1 Insert the specimen fixture with specimen in place into the test cabinet. The bottom of the specimen should be 0.75 inches above the level at the top of the burner. When testing two-sided blankets, the “nap” side (the downy or fuzzy surface of the fabric) should be exposed to the flame.

D8.6.2.2 Close the cabinet door, and keep it closed during the test. It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

D8.6.2.3 The timer must be started immediately on positioning the burner. Position the burner so that it is directly under the geometric center of the test specimen. This is shown in figure D8-6.

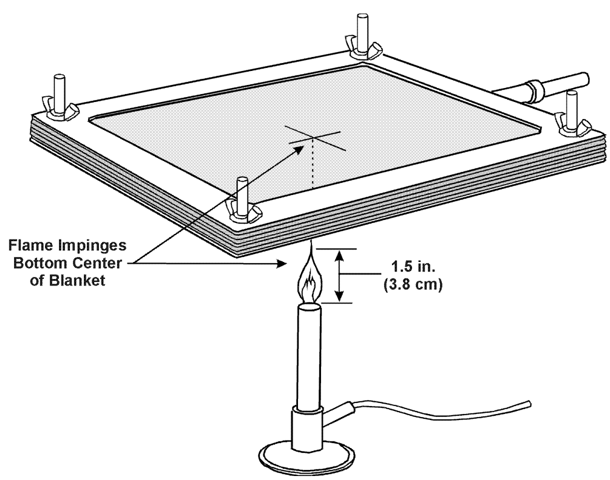


Figure D8-6. Horizontal test fixture with four-ply blanket sample

D8.6.2.4 Apply the flame for 12 seconds and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off. If the flame extinguishes during the ignition time for any reason, the test will be rerun.

D8.6.2.5 If flaming material falls from the test specimen, determine the drip flame time for the specimen.

D8.6.2.6 Determine the flame time for the specimen.

D8.6.2.7 After all flaming ceases, the cabinet door should be opened slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing the smoke and fumes.

NOTE: The operator should refer to the facility's safety manual for further information dealing with smoke and flammability byproducts.

D8.6.2.8 Remove any material that fell from the specimen to the bottom of the cabinet. If necessary, clean the test cabinet window prior to testing the next specimen.

D8.7 Report

D8.7.1 Material Identification

Fully identify the material tested, including fiber type and type of FR treatment, if known.

D8.7.2 Test Results

D8.7.2.1 Ignition Time

Report the ignition time.

D8.7.2.2 Flame Time

Report the flame time for each specimen tested. Determine and record the average value for flame time.

D8.7.2.3 Drip Flame Time

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

D8.8 Requirements

D8.8.1 Flame Time

The average flame time for all of the specimens tested will not exceed 15 seconds.

D8.8.2 Drip Flame Time

The average drip extinguishing time for all the specimens tested will not exceed 5 seconds.

Chapter D9
Smoke Test for Insulated Aircraft Wire

D9.1 Scope

D9.1.1 Applicability

This test method can be used to determine the smoke-generating characteristics of insulated aircraft wire using a smoke-density chamber.

D9.2 Definitions

D9.2.1 Specific Optical Density (D_S)

Specific optical density is a dimensionless measure of the amount of smoke produced per unit area by a material when it is burned. In this test, the maximum value of D_S that occurs during the first 20 minutes of a test, D_m, is reported.

NOTE: In this test, the maximum specific optical density ($20D_s$) should be at 20 minutes; however, it is possible for the maximum to occur earlier in the test because of coagulation or adsorption of smoke particles to the walls of the chamber.

D9.3 Test Apparatus

D9.3.1 Required Equipment

The test chamber and related equipment (e.g., radiant heat furnace, heat-flux density gauge, specimen holder, photometric system, straight pilot burner) will be as defined below:

D9.3.1.1 Test Chamber

The test chamber will be a square-cornered box with inside dimensions of 36 ± 0.13 inches (914 ± 3 mm) wide, 24 ± 0.13 inches (610 ± 3 mm) deep, and 36 ± 0.13 inches (914 ± 3 mm) high. A typical test chamber is shown in figure D9-1. The location or size of such items as the chamber door, chamber controls, and flowmeters is optional, except as mandated in the following sections.

NOTE: Commercially available panels of porcelain-enameled steel (interior surface) permanently laminated to a magnesia insulation core and backed with galvanized steel (exterior surface) have been found acceptable.

A thin sheet of transparent material can be placed over optical and viewing windows to protect them against corrosive components in the smoke.

D9.3.1.1.1 The interior surfaces (except for the chamber door and vents) will be porcelain-enameled metal or equivalent coated metal that is resistant to chemical attack and corrosion, and suitable for periodic cleaning.

D9.3.1.1.2 The chamber will be equipped with a door, similar to that indicated in figure D9-1, to provide convenient access for changing test specimens and for cleaning the chamber walls as required. The door will have a viewing window to observe the chamber interior during a test, especially when any of the flamelets extinguish.

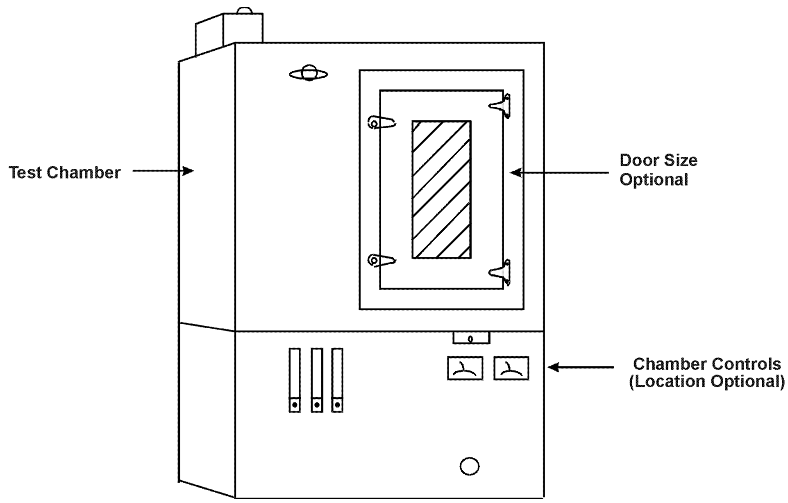


Figure D9-1. Typical smoke-density chamber

D9.3.1.1.3 An inlet-outlet vent for pressure equalization will be provided. The vent and chamber door will have a seal so that when it is closed during tests, there will be no leakage of chamber contents, and a small positive pressure can be developed and maintained inside the test chamber.

D9.3.1.2 Manometer

A device such as a manometer or pressure transducer will be provided to monitor chamber pressure and leakage. The device will have a range of up to 6 inches (152 mm) of water and be connected to a suitable port in the test chamber.

D9.3.1.3 Pressure Regulator

A pressure regulator will be provided that consists of a water-filled bottle vented to a suitable exhaust system and a piece of tubing, not to exceed 10 feet (305 cm) in length, that has an inside diameter of at least 1 inch (25 mm). One end of the tubing will be connected to a port within 6 inches of the top of the chamber; the other end of the tubing will be held in position 4 inches (102 mm) below the water surface.

NOTE: Venting the water-filled pressure regulator to a suitable exhaust system is necessary to prevent the buildup of unknown contaminates in the laboratory area. The location of the pressure-relief tube should be on or within 6 inches of the top of the chamber.

D9.3.1.4 Test-Chamber Wall Thermocouple

The temperature of the test-chamber wall will be monitored by a thermocouple suitable for measuring a temperature of 35°C. The thermocouple will be mounted with its junction secured to the geometric center of the inner-rear wall panel of the chamber using an electrical insulating disk cover.

D9.3.1.5 Electric Power

Six hundred fifty watts of 115V, 60 Hz, single-phase electric power will be provided for the radiant heat furnace and accessories. If line voltage fluctuations exceed 2.5 percent, a constant voltage transformer will be provided.

NOTE 1: A powerstat variable autotransformer, Type 21, from Superior Electric Co., Bristol, Connecticut, or equivalent, has been found satisfactory to transform electric power to that required by the chamber.

NOTE 2: A constant voltage transformer from Sola Electric Co., Chicago, Illinois, Catalog Number 23-13-150, or equivalent, has been found satisfactory. A Sorenson Model 200S AC voltage regulator or equivalent has been found satisfactory.

D9.3.1.6 Radiant Heat Furnace

An electric furnace and associated controlling devices, such as shown in figures D9-2 and D9-3, will be provided, which are capable of providing a constant thermal flux density of 2.5 ± 0.05 W/cm^2 (2.2 ± 0.04 Btu/ft^2/sec) on the specimen surface.

NOTE: Furnace model P/N 6806025700 from Newport Scientific has been found acceptable.

D9.3.1.6.1 Furnace Construction

The dimensions shown in figure D9-2 for the electric furnace are critical. The furnace will be located centrally along the long axis of the chamber with the opening facing toward, and approximately 12 inches (305 mm) from, the right wall. The centerline of the furnace will be approximately 7.75 inches (197 mm) above the chamber floor.

D9.3.1.6.2 Heating Element

The heating element will consist of a coiled wire capable of dissipating approximately 525 watts. With the furnace installed, the heating element will be positioned so that the coil loops are at the 12 o'clock position, as shown in figure D9-3.

D9.3.1.6.3 Furnace Control System

The furnace control system will be capable of controlling the radiant heat output at the required level of 2.5 ± 0.05 W/cm^2 (2.2 ± 0.04 Btu/ft^2/sec), as measured by the heat-flux density gauge, under steady-state conditions, with the chamber door closed for at least 5 minutes. The control system will consist of an AC solid-state voltage or power controller and a voltmeter or other means for monitoring the electrical input.

NOTE: A Model 470 Series power controller manufactured by Eurotherm™, a Model 3AEV1B10C1 Triac manufactured by GE, or equivalent, has been found satisfactory.

The furnace control system should be a reputable unit that provides the parameters to fulfill the requirements of the furnace.

The use of a digital voltmeter to monitor the furnace voltage output and a digital amperemeter to monitor the furnace current is recommended.

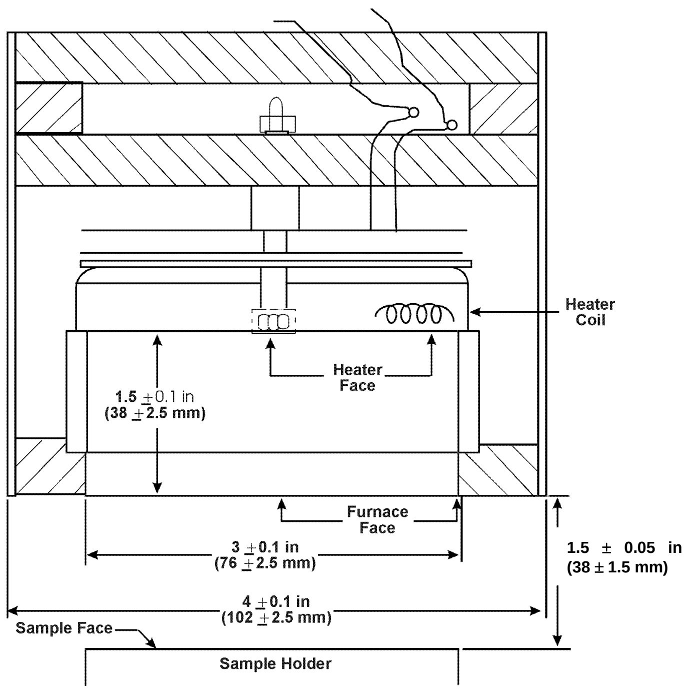


Figure D9-2. Furnace section

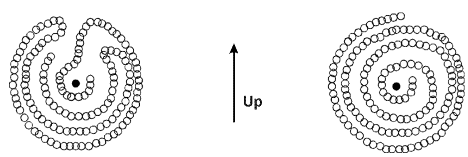


Figure D9-3. Heater orientation

D9.3.1.6.4 Heat-Flux Density Gauge

An air-cooled heat-flux density gauge will be provided for calibrating the output of the radiant heat furnace. The heat-flux density gauge will be a circular foil type, the operation of which has been described by Gardon.

NOTE: A thermocouple system capable of measuring 200° ± 2°F is an acceptable alternate method to monitor the body temperature of the heat-flux density gauge. See

Gardon, R., "An Instrument for the Direct Measurement of Intense Thermal Radiation," Review of Scientific Instruments, Vol. 24, 1953, pp. 360–370.

D9.3.1.6.4.1 Compressed air at a pressure of 15–30 psi (0.1 to 0.21 MPa) will be provided to cool the heat-flux density gauge. The body temperature of the heat-flux density gauge will be monitored with a thermometer having an accuracy of 2°F (1°C) at 200°F (93°C) in a 0.5- by 0.5- by 1.5-inch-long (13- by 13- by 38-mm) brass or copper well drilled to accept the thermometer with a close fit. Silicone grease will be used to provide good thermal contact. The circular receiving surface of the heat-flux density gauge will be spray coated with an infrared absorbing black paint. The heat-flux density gauge will be calibrated calorimetrically using a procedure that is acceptable to the FAA Administrator.

D9.3.1.7 Pilot Burner

The straight burner must be used for flaming tests on insulated wire specimens, as shown in figure D9-4. The pilot burner should be aligned with a sample holder and backing board in place. Care should be taken to ensure accurate positioning of the pilot tips to the sample holder.

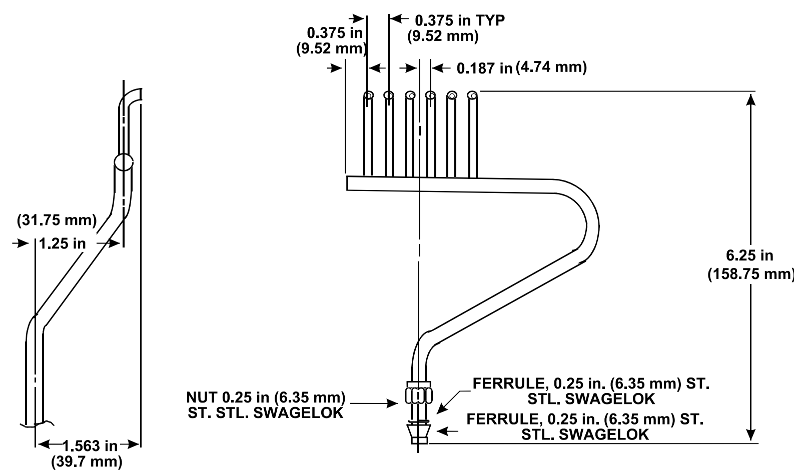


Figure D9-4. Straight-tip burner

D9.3.1.7.1 The six tubes will be fabricated from stainless-steel tubing having an outer diameter of 0.125 inch (3.2 mm) and an inner diameter of 0.055 inch (1.4 mm) ± 0.001 inch (0.025 mm). The six tubes will be attached to a common manifold, as shown in figure D9-5, fabricated from stainless-steel tubing having an outer diameter of 0.25 inch (6.4 mm) and a wall thickness of 0.035 inch (0.9 mm). One end of the manifold will be closed, and the other end will be attached to a gas supply fitting on the chamber floor.

D9.3.1.7.2 The pilot burner will be centered in front of and parallel to the specimen holder. The tips of the six outer tubes will be placed 0.25 ± 0.06 inch (6.4 ± 1.6 mm) above the lower opening of the specimen holder and 0.25 ± 0.03 inch (6.4 ± 0.8 mm) from the face of the specimen surface.

D9.3.1.8 Pilot-Burner Fuel

The gas fuel for the pilot burner will be prepared by mixing filtered oil-free air with 95 percent minimum purity propane and feeding the mixture to the pilot burner. Each gas will be metered through separate, calibrated flowmeters and needle valves. The air/propane mixture will consist of an airflow rate equivalent to 0.018 ± 0.001 ft^3/min (500 ± 20 cm^3/min) at STP and a propane flow rate equivalent to 0.0018 ± 0.0001 ft^3/min (50 ± 3 cm^3/min) at STP. The compressed air supply will be fed to its flowmeter at 20 ± 5 psi (0.14 ± 0.03 MPa) and the propane at 15 ± 3 psi (0.1 ± 0.02 MPa).

NOTE: Commercially bottled propane has been found acceptable.

D9.3.1.8.1 The visible parts of the pilot-burner flamelets should be approximately 0.25 inch (6 mm) long with a luminous inner cone approximately 0.13 inch (3 mm) long, as shown in figure D9-6. If the flamelets are not that approximate size, there is probably difficulty with the air/propane fuel mixture or flow rate(s), in which case the accuracy of the flowmeters should be checked.

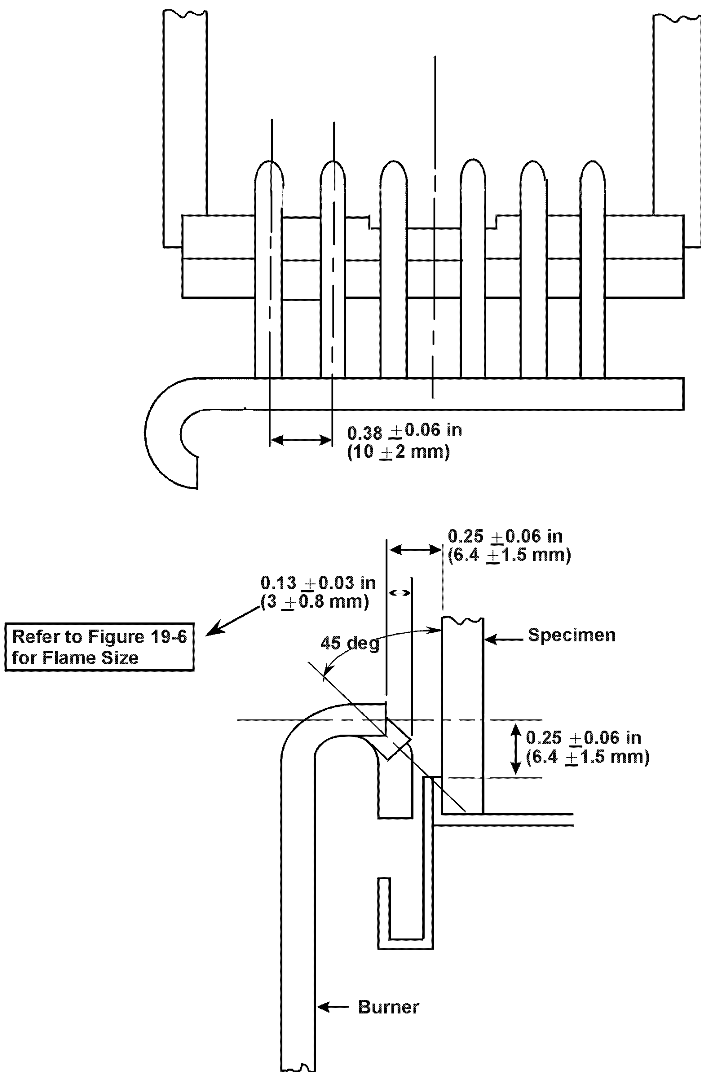


Figure D9-5. Alignment of holder and burner

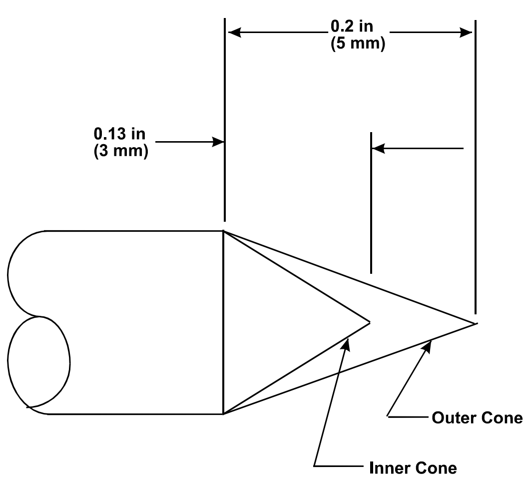


Figure D9-6. Flame size

D9.3.1.9 Specimen Holder

The specimen holder will consist of a stainless-steel frame, a backing made of insulation millboard, a spring and retaining rod to secure the specimen in place, and aluminum foil for wrapping the specimen.

D9.3.1.9.1 Specimen-Holder Frame

The specimen-holder frame will be fabricated of stainless-steel sheet by bending and brazing (or spot welding) stainless-steel sheet of a 0.025 ± 0.002-inch (0.64 ± 0.05-mm) nominal thickness to conform in shape and dimension to figure D9-7. The frame will be at least 1.5 inches (38 mm) deep and will provide an exposed specimen surface that is nominally 2.56 by 2.56 inches (65 by 65 mm) and that is at least 6.5 inches^2 (4194 mm^2) in area.

NOTE: Sample holders must be compared with one another for accuracy; for example, top and bottom mounting devices must be consistent with each other. It has been noted that misalignment between holders does result in pilot position errors.

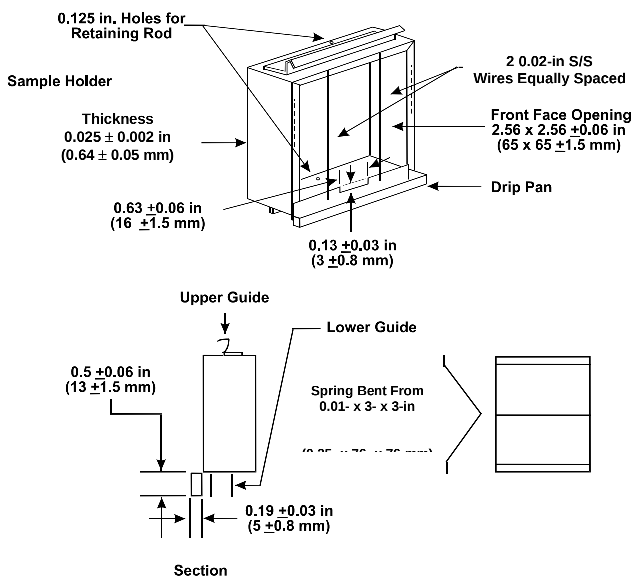


Figure D9-7. Details of specimen holder

D9.3.1.9.1.1 A drip pan to catch and retain dripping material will be attached to the bottom front of the holder.

D9.3.1.9.1.2 Guides to permit accurate alignment of the exposed specimen area in front of the furnace opening will be attached to the top and bottom of the holder frame.

D9.3.1.9.2 Specimen Backing

A piece of insulation millboard will be used as a backing for the specimen and as a simulated blank specimen. The millboard will be nominally 0.5 inch (13 mm) thick with a density of 50 ± 10 lb/ft^3 (0.8 ± 0.16 g/cm^3) or equivalent. Pieces will be cut 2.91 ± 0.03 by 2.91 ± 0.03 inches (74 ± 1 by 74 ± 1 mm) to fit inside the specimen holder.

NOTE: A recommended material is Marinite I.

D9.3.1.9.3 Retaining Spring

A spring bent from 3- by 2.94- by 0.01-inch thick (76- by 75- by 0.25-mm) stainless-steel sheet will be used with a stainless-steel retaining rod to securely hold the specimen and millboard backing in position during testing.

D9.3.1.9.4 Aluminum Foil

Smooth aluminum foil that is 0.0012 ± 0.0005 inch (0.03 ± 0.01 mm) thick will be used to wrap test specimens prior to their insertion in the holder.

NOTE: Aluminum foil used for household food wrapping is acceptable.

D9.3.1.10 Support for Radiant Heat Furnace and Specimen Holder

A typical support frame to support the radiant heat furnace and specimen holder is shown in figure D9-8. This support frame will have a provision to establish accurate alignment for the furnace opening so that it is 1.5 ± 0.031 inches (38 ± 1 mm) away from, parallel to, and centered with the exposed specimen surface. Adjustment screws will be provided to align the furnace with reference to the specimen. The framework will have two 0.38-inch (10-mm) diameter transverse rods of stainless steel to accept the guides of the specimen holder. The rods will support the holder so that the exposed specimen surface is parallel to the furnace opening. Spacing stops will be mounted at both ends of each rod to permit rapid and accurate lateral positioning of the specimen holder. An externally operated control rod will be provided to replace the test specimen with the blank specimen holder in front of the furnace.

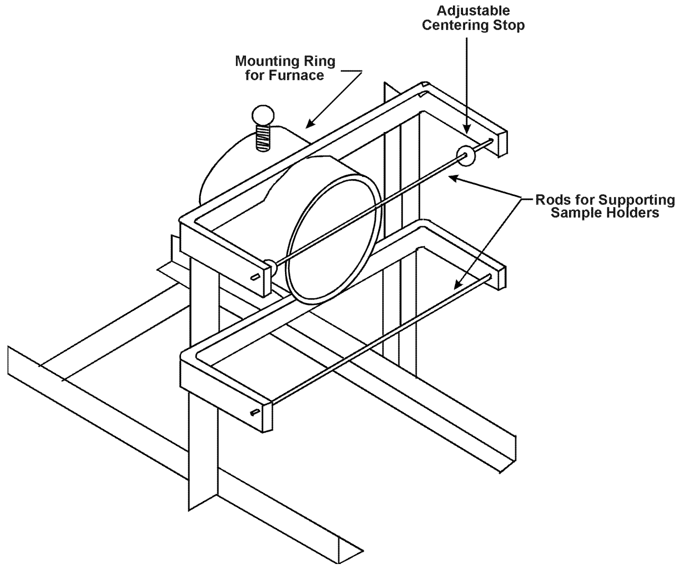


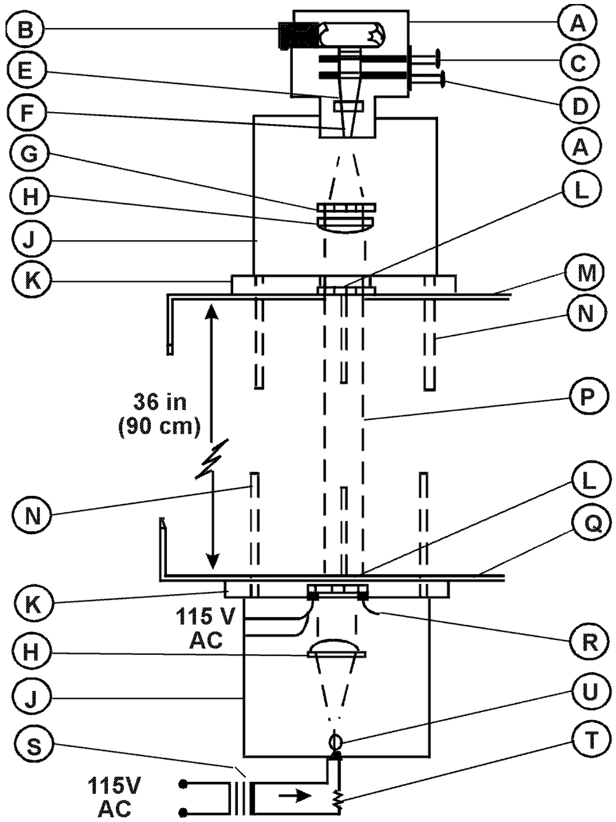
Figure D9-8. Typical furnace support

D9.3.1.11 Photometric System

A photometric system capable of detecting light transmittance values of 1 percent minimum to an accuracy of 0.03 percent will be provided. The system will consist of a light source and photomultiplier tube that are oriented vertically (to reduce measurement variations due to optical density and stratification of the smoke in the chamber during the test), a photomultiplier microphotometer that converts the photomultiplier tube output to relative intensity, and/or a strip chart recorder or other suitable means to record light transmission versus time. A typical system is shown in figures D9-9 and D9-10.

D9.3.1.11.1 Light Source

The light source will be an incandescent lamp mounted in a sealed, light-tight box below the chamber floor and operated at a light-brightness temperature of 2200 ± 100 K, controlled by a constant-voltage transformer. The box will contain the necessary optics to produce a collimated light beam 1.5 ± 0.13 inches (38 ± 3 mm) in diameter, passing vertically up through the chamber. The light source and its optics will be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber bottom panel and sealed to prevent leakage of chamber contents. To minimize smoke condensation, the window will be provided with a ring-type electric heater mounted in the light-tight box, out of the light path, that maintains a minimum window temperature of 125°F (52°C) on the surface of the window inside the chamber.



A - Photomultiplier Housing
B - Photomultiplier Tube and Socket
C - Upper Shutter Blade with ND2 Filter over One Aperture
D - Lower Shutter Blade with Single Aperture
E - Opal Diffuser Filter
F - Aperture Disk
G - Neutral Density Compensating (from set of 9)
H - Lens 7 Diopter (2)
J - Optical System Housing (2)
K - Optical System Platform (2)
L - Optical Windows (2)
M - Chamber Roof
N - Alignment Rods (3)
P - Parallel Light Beam 1.5 in (37.5 mm) Diameter
Q - Chamber Floor
R - Optical Window Heater, Silicone-Fiberglass 50W/115V
S - Regulated Light Source Transformer, 115/125 V-6 V
T - Adjustable Resistor, Light Source Adjusted for 4V
U - Light Source

Figure D9-9. Photometer detail

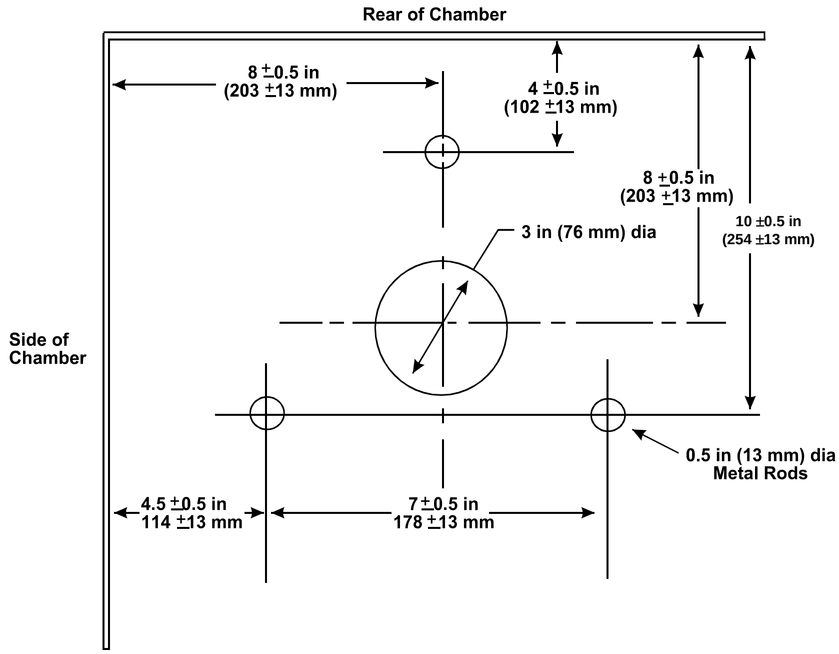


Figure D9-10. Optical system location plan view

D9.3.1.11.2 Photomultiplier Tube

The photomultiplier tube will have an S-4 linear spectral response and a dark current less than 10^{-9} ampere.

NOTE: A thin sheet of transparent material can be placed over optical and viewing windows to protect them from corrosive components in the smoke.

D9.3.1.11.2.1 The photomultiplier tube and associated optics will be mounted in a second light-tight box located above the chamber ceiling directly opposite the light source. The photomultiplier tube and its optics will be isolated from the chamber atmosphere by a glass window mounted flush with the chamber ceiling panel and permitting viewing a cross section of 1.5 ± 0.13 inches (38 ± 3 mm). The window will be sealed to prevent the leakage of chamber contents.

D9.3.1.11.3 Microphotometer

The microphotometer will be capable of converting the signal from the photomultiplier tube to relative intensity/optical density. The microphotometer/photomultiplier tube combination will be sensitive enough that the microphotometer can be adjusted to produce a full-scale reading (100 percent relative light intensity or optical density = 1) using the photomultiplier tube's response (output) to the light source when a filter of 0.5 or greater optical density is placed in the light path.

D9.3.1.11.4 Alignment Fixture

The two optical windows and their housings will be kept in alignment and spaced 36 ± 0.125 inches (914 ± 3 mm) apart with an alignment fixture consisting of three metal rods, 0.5–0.75 inch (13–19 mm) in diameter, fastened securely to 0.31-inch-thick (8-mm) externally mounted top and bottom plates and symmetrically arranged about the collimated light beam.

D9.3.1.11.5 Optical Filters

A set of nine neutral color optical filters—0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 optical density—will also be provided. The optical filters, one or more as required, may be mounted in the light path in the optical measuring system to compensate for the sensitivity of the photomultiplier tube. These filters can also be used to adjust the photometric system as the light source/photomultiplier tube changes sensitivity through aging, discoloration, or deterioration of the optical windows occurs.

D9.3.1.11.6 Recorder

A recording device will be furnished that provides a record of the percent of light transmission/optical density versus time during the test. The record will consist of either a continuous curve on a chart recorder or discrete values taken at least every 5 seconds with a computerized data-acquisition system.

D9.3.1.12 Exhaust Hood

A method for removing the chamber contents after each test will be provided. A fitting for removing the chamber contents can be connected to a suitable exhaust hood. Locating an exhaust hood directly above the smoke-chamber door is recommended as an additional safety device.

D9.3.1.13 Conditioning Chamber

A conditioning chamber capable of maintaining test specimens at a temperature of 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity will be provided.

D9.3.2 Recommended Equipment

The following items are recommended, but not required:

Digital Voltmeter—Preferred to monitor furnace voltage and heat-flux density gauge output. A Keithley Model 165 Autoranging Multimeter or equivalent has been found acceptable.

Constant Voltage Transformer—A constant voltage transformer is recommended for all installations (see section D9.3.1.5).

Pilot Burner Positioning Fixture—A fixture to accurately position the pilot burner is recommended to establish a precise pilot-burner position for testing and to facilitate accurate repositioning of the pilot burner after removal and replacement (see figure D9-10).

Automated Igniter System—An automated igniter system is recommended to relight the pilot burner flamelets to ensure that none of them extinguish for more than 3 seconds during the test. If an electric sparking device is used, an appropriate method of suppression and equipment shielding must be applied to have no interference with ability of data-acquisition equipment to accurately record data. Weyerhaeuser Fire Technology Laboratory, Report #9001 in house, describes an automated sparking system. Another system for reignition utilizes a small movable propane flame.

D9.4 Test Specimen Selection and Preparation

D9.4.1 Specimen Number

A minimum of three specimens will be prepared and tested.

NOTE: Conditions may require as many as six specimens. Specimens should be marked with an arrow by manufacturers or operator for a consistent direction for test purposes.

D9.4.2 Specimen Size

Insulated wire specimens, 16 AWG and smaller, will be wrapped on the frame, as shown in figure D9-11. Insert the end of a 10-foot length of insulated wire through one of the holes in the frame, and complete the wrap by inserting the finishing end of the insulated wire through the unused hole and under the last turn to prevent unwinding. Specimens 14 AWG and larger should be cut approximately 3 inches in length and laid side by side, covering the entire opening in the front of the specimen holder. This is readily accomplished by first covering the front of the Marinite millboard with aluminum foil and inserting it and the spring into the specimen holder. The pieces of wire are then inserted through the front of the holder and held vertically. This is shown in figure D9-12.

D9.4.3 Specimen Orientation

Insulated wire specimens will be tested only in a vertical orientation.

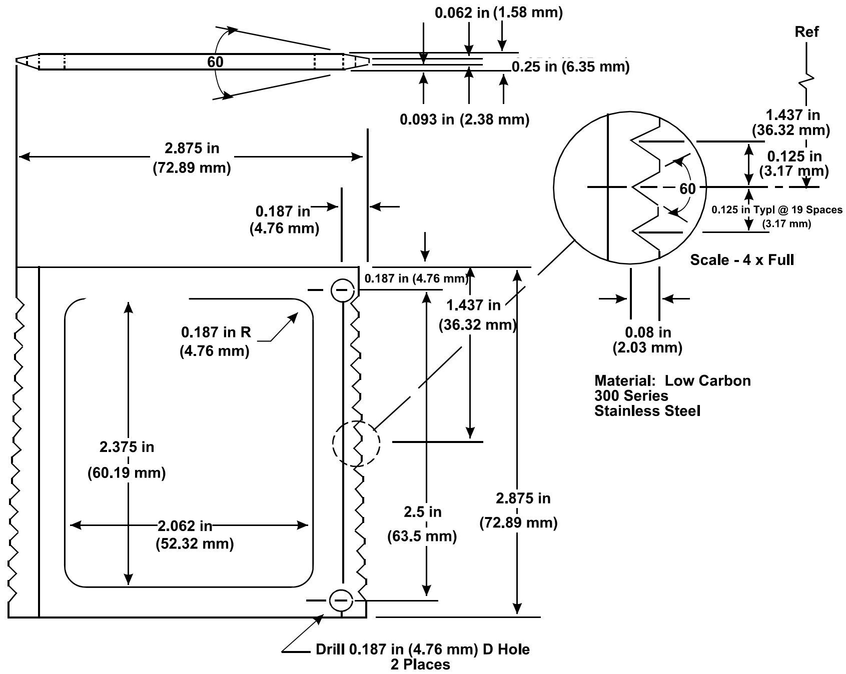


Figure D9-11. Wire holding frame

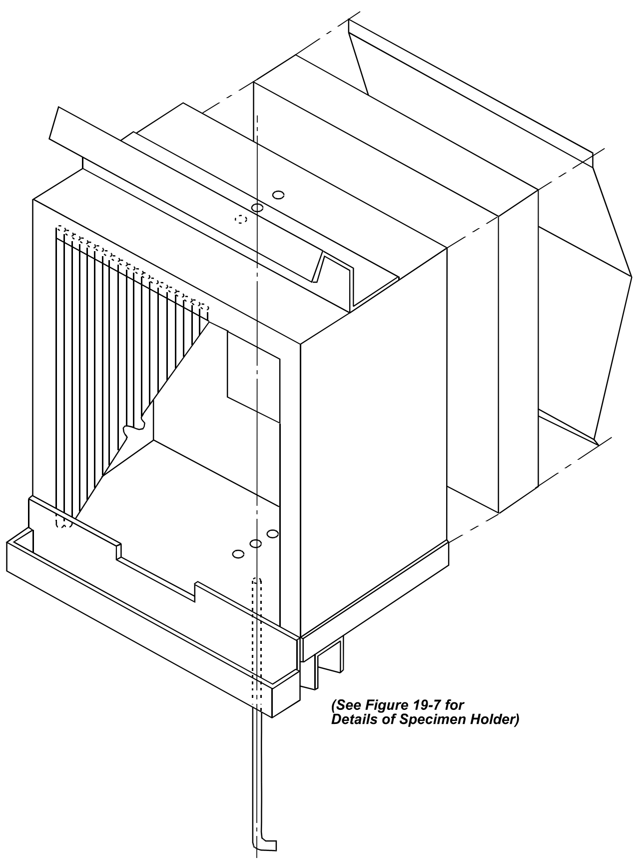


Figure D9-12. Larger gauge wire mounted in specimen holder

D9.5 Test-Chamber Calibration

D9.5.1 Furnace Protection

Prepare a blank specimen consisting of 0.5-inch-thick alumina-silica millboard mounted in a specimen holder (see section D4.3.1.9.2). To reduce problems with the stability of the heat-flux density from the furnace, maintain the blank specimen in front of the furnace when no testing or calibration is being conducted.

D9.5.2 Periodic Calibration Procedure

Conduct a periodic calibration of the system as follows:

D9.5.2.1 Photometric System

The photometric system used in this test method is an inherently linear device. Check the system for proper photocell alignment. Verify, at least every 2 months, the linearity of the system using a set of neutral optical density filters or equivalent. Check the system more frequently if erratic behavior is observed or suspected.

D9.5.2.2 Furnace

Use the approved heat-flux density gauge to monitor the heat-flux density produced by the furnace. Place the heat-flux density gauge on the horizontal rods of the furnace support framework and accurately position it in front of the furnace opening by sliding and displacing the blank specimen holder against the spacing stop (see section D4.3.1.10). With the chamber door closed and the inlet vent opened, adjust the compressed air supply to the heat-flux density gauge cooler to maintain its body temperature at 200° ± 50°F (93° ± 3°C). Adjust the setting of the furnace control voltage or power controller to obtain the calibrated millivolt output of the heat-flux density gauge corresponding to a steady-state irradiance of 2.5 ± 0.05 W/cm^2 (2.2 ± 0.04 Btu/ft^2/sec). After the irradiance has reached the required value and has remained steady-state for at least 5 minutes, remove the heat-flux density gauge from the chamber and replace it with the blank specimen holder.

D9.5.2.2.1 Record the setting of the furnace control voltage or power controller, and use this setting until a future calibration indicates it should be changed.

D9.5.2.3 Chamber Leak Test

Test the smoke-density chamber leak rate at least once a month or more often if loss of chamber pressure is suspected, using the following procedure:

D9.5.2.3.1 Place the heater switch in the OFF position. Close the inlet vent and the chamber door.

D9.5.2.3.2 Pressurize (e.g., by bleeding in a small amount of air through the port used for the heat-flux density gauge) the chamber to at least 3 inches of water above ambient, as indicated by the manometer.

D9.5.2.3.3 Note the chamber pressure. Verify that the chamber-pressure leakage rate is less than 2 inches of water in 2 minutes.

D9.5.2.4 Total System

Check the total system at least once a month by testing a material that has shown a consistent specimen-to-specimen D_m value in the range of 1 to 5 D_m and that is and will continue to be readily available. Maintain a record of the test results obtained; if erratic values are observed, identify and correct any instrumental or operational deficiencies.

D9.5.3 Chamber Cleaning

Clean the optical system windows, viewing window, chamber walls, and specimen holders as follows:

D9.5.3.1 Optical System Windows

Clean the exposed surfaces of the glass separating the photo detector and light source housings from the interior of the chamber after each test. Clean the top window first, then the bottom window, using a nonabrasive cloth dampened with a suitable cleaner. Dry the window to prevent streaking or film buildup. Do not use any cleaners that contain wax, which will cause the smoke to adhere to the glass more quickly.

D9.5.3.2 Viewing Window

Clean the viewing window periodically as required to allow viewing of the chamber interior during testing. The same cleaners used in section D4.6.3.1 have been found satisfactory.

D9.5.3.3 Chamber Walls

Clean the chamber walls periodically to prevent excessive buildup of smoke products. An ammoniated spray detergent and nonabrasive scouring pad have been found effective.

D9.5.3.4 Specimen Holders

Remove any charred residue on the specimen holders and horizontal rods securing the holder position to prevent contamination of subsequent specimens.

D9.6 Procedure

D9.6.1 Each day, prior to testing, adjust the chamber as follows:

D9.6.1.1 Calibrate the furnace output according to section D4.6.2.3 to determine the correct furnace voltage.

D9.6.1.2 Balance the photomultiplier dark current and set the clear beam reading to 100 percent relative transmission or to optical density 0.00.

D9.6.1.3 Set the photomultiplier scale at 100. Shut lower shutter blade (D) directly below photomultiplier tube (B) (see figure D9-9). Set your data-recording device to 0.

NOTE: During testing at the FAA William J. Hughes Technical Center, a software-related problem was discovered with the calculation of D_s during some NBS chamber testing. It is possible that during the initial readings taken with a blanked-off photcell, there should be some residual voltage reading (±1 millivolt). This is too small a value to be read visually, but it can be detected by the computer. The problem is that the current software assumes the initial value is 0, and the results are altered accordingly. Because the specific optical density is a logarithmic function, the problem is magnified the higher the value, making the D_s at the approximate pass/fail point of 200 critical. A ±1 millivolt initial reading can change an actual D_s of 200 to 175/224, respectively. The fix for this problem is to blank off the photocell prior to each test and let the computer set the "zero."

Computer users could use the following procedure for the computer program—close the shutter, let the computer read baseline volts (0) (mVb), and determine:

$$\text{Slope} = \frac{100}{(\text{mV}_H - \text{mV}_b)}$$

$$\%\ \text{L.T.} = (\text{mV} - \text{mVb}) * \text{Slope}$$

D9.6.2 Conduct the test procedure as follows:

D9.6.2.1 Ensure that the specimen(s) have been properly prepared per sections D4.4.1 through D4.4.5.

D9.6.2.2 Ensure that the chamber wall temperature is 95° ± 4°F (35° ± 2°C).

D9.6.2.3 Ensure that the furnace voltage has been set correctly.

D9.6.2.4 Set the clear beam reading to 100 percent relative transmission or to optical density 0.00 (see section D4.7.1.2).

NOTE: This procedure is described in AMINCO NBS Smoke Density Chamber, Catalog No. 4-5800B, Instruction 941B.

D9.6.2.5 Position the pilot burner in front of and parallel to the specimen holder. Turn on the pilot burner fuel (see section 6.3.1.8) and light the flamelets on the pilot burner. Make sure that all flamelets are ignited and properly adjusted.

D9.6.2.6 Open the test-chamber door and place the specimen holder on the support. Immediately push the specimen holder into position in front of the furnace, displacing the blank specimen holder to the prepositioned stop, and close the chamber door and inlet vent. For chambers with an external device to move the specimen holder in front of the furnace, place the holder on the support, close the door, and then slide the sample into position and simultaneously start the timer and recorder for light transmission.

D9.6.2.7 Continue the test for a minimum of 20 minutes (1200 seconds).

D9.6.2.8 Record the percent of light transmission/optical density versus time (minutes) during the test.

D9.6.2.9 Monitor the chamber pressure during the test. If negative pressure (below ambient atmospheric) develops, open the inlet valve slightly to relieve pressure.

D9.6.2.10 If one or more pilot lights extinguish at the start of the test (first 5 seconds), stop the test, relight the flames, and start the test again. If one or more pilot lights extinguish during the first 10 minutes of the test, the test must be aborted and a new sample of wire run. If one or more pilot lights extinguish after 10 minutes, continue the test, making note of the time of extinguishment and the number of pilot lights extinguished.

D9.6.2.11 At the termination of the test, remove the test-specimen holder from its position in front of the furnace and replace it with the blank specimen holder using the exterior control rod. Begin exhausting the chamber of smoke within 1 minute by opening the door and the inlet vent (and exhaust vent, if used). CAUTION: The door should be opened gradually to avoid exposure to the chamber contents, which may be toxic.

D9.6.2.12 Continue to exhaust the chamber until all smoke has been removed.

D9.6.2.13 Clean the windows to the housings for the photomultiplier tube and the light source per section D4.6.3.1.

NOTE: Ethyl alcohol, methyl ethyl ketone, or equivalent has been found satisfactory.

D9.6.2.14 Record the D_s for each specimen at the 20-minute point. Calculate and record the maximum specific optical density, D_m, during the 20-minute (1200-second) test for each specimen according to the formula:

$$\begin{aligned} D_m &= (V / LA)\log_{10}(100 / T_m) \\ &= 132 \log_{10}(100 / T_m) \end{aligned}$$

where:

V	=	chamber volume = 18.00 ft^3 (0.510 m^3)
L	=	light path length = 3.00 ft (0.914 m)
A	=	exposed specimen area = 6.57 in^2 (0.00424 m^2)
T_m	=	minimum percent light transmission during 20 minutes
$\log_{10}(100/T_m)$	=	maximum optical density during 20 minutes

D9.6.2.15 Calculate and record the average D_m value and its standard deviation for all the specimens tested for each part/construction. Use the actual D_m values for this average. Do not use the average light transmission value to determine the average D_m value.

D9.7 Report

D9.7.1 Report a complete identification of the part/construction tested such as insulation type or gauge.

D9.7.2 Report the number of specimens tested (the average D_m).

D9.7.3 Report any additional data or observations, as applicable or required by the test plan.

Chapter D10
Dry Arc Tracking Test Procedure

D10.1 Purpose

The Dry Arc Tracking Test for wire insulation provides a comparative assessment of insulation degradation and arc propagation of wires in a bundle when subjected to electrical arcing. This test method is for use in obtaining comparative data.

D10.2 Test Specimens

Twenty-gauge wires were selected as test standards because this size is one of the most commonly used gauges in transport category aircraft. At least three tests must be run on each wire insulation material.

D10.2.1 Specimen (Preparation)

Cut seven segments of wire, each 14 inches in length. Strip 0.1875 inches of insulation from both ends of each wire.

D10.2.1.1 Assemble the wires in a six-around-one configuration, as shown in figure D10-1.

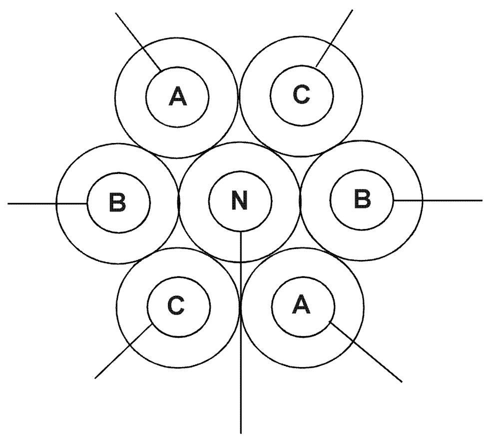


Figure D10-1. Wire bundle configuration

D10.2.1.2 Arrange the wires straight and parallel. Using a high-temperature lacing tape, mil-tie the wires into a bundle, making a tie 1/4 inches back on the insulation from one set of stripped ends. The other ends are left untied to better facilitate connecting to test leads from a power supply. Make a second tie 2 inches farther back from the first tie. After tying the bundle, apply a small amount of finely powdered conductive graphite to the exposed wire ends (Graphite, 96 percent, 325 Mesh Technical, J.T. Baker, Inc., is acceptable). This can be accomplished by dipping the wire ends directly into a container of the graphite powder. Ensure that the graphite does not get on the wire insulation.

D10.2.2 Electrical Connections

Support the bundle horizontally in a laboratory stand using two clamps, approximately 8 inches apart. Position one clamp 0.50 inch from the bundle tie farthest in from the graphite powdered wire ends. The other clamp is used to support the wires toward the end connected to the power supply.

D10.2.2.1 Connect each of the seven 20-gauge wires to a 7.5-amp aircraft circuit breaker. (This size conforms to standards for circuit-breaker protection of bundled 20-gauge airplane wiring.) The 7.5-amp breakers can be mounted in a test box with alligator clips on seven test leads to facilitate connecting to the test wires. Use a three-phase Wye connected power supply derived from a rotary machine of not less than 5 KVA rating, delivering 215 volts line-to-line at 400 cycles (see figure D10-2).

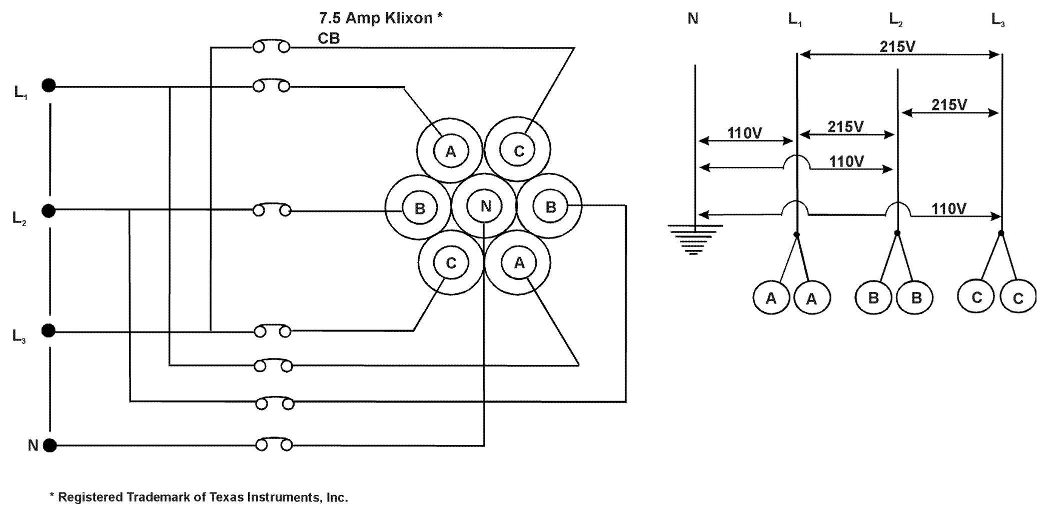


Figure D10-2. Electrical connections

D10.2.3 Protective Screen and Test Location

A transparent screen should be used to protect personnel from molten metal and other debris that may be ejected from the specimen during the arc test. Use eye protection for visual observation of the arc. Conduct the test in a ventilated, draft-free location to remove any potentially toxic fumes. Perform testing at room temperature.

D10.3 Procedure

Initiate the test arc by closing a power contactor. Then, leaving the contactor closed, visually examine, but do not touch, the wires in the bundle after the initial arc. Following that, reset each tripped circuit breaker one time only.

D10.4 Report

Report the following for each test:

1. A description of the new wire tested

2. The power, frequency, and voltage of the three-phase power supply

3. Any damage to the wire bundle after the initial arc

4. The number of open circuit breakers after the initial arc

5. A description of damage to the insulation of each wire in the bundle, including the length of insulation damage, tube effects, and welds, after resetting the circuit breakers

3.1 CHAPTER D11
DRY ARC-PROPAGATION RESISTANCE

D11.1 Purpose

The dry arc-propagation resistance test for wire insulation provides an assessment of the ability of an insulation to prevent damage in an electrical arc environment. In service, electrical arcs may originate from a variety of factors, including insulation deterioration, faulty installation, and chafing. It has been documented that results of an arc-propagation test may vary slightly because of the method of arc initiation. Therefore, a standard test method must be selected to evaluate the general arc-propagation resistance characteristics of an insulation. This test method initiates an arc with a vibrating blade. The arc-propagation resistance is defined by the length of arc-propagation damage along the wires in contact with the blade and by the extent of damage to all adjacent wires undamaged by the vibrating blade. The test also evaluates the ability of the insulation to prevent further arc-propagation when the electrical arc is reenergized. The power supply, test current, circuit resistances, and other variables are optimized for testing 20-gauge wires. The use of other wire sizes may require modification of test variables.

D11.2 Test Equipment

The following equipment shall be used:

D11.2.1 An abrader blade made from 6061-T6 aluminum material. Use a 60-grit size grinding wheel or a 60-grit sanding belt to sharpen the blade. A typical abrader blade is shown in figure D11-1. Use the blade-sharpening fixture shown in figure D11-2.

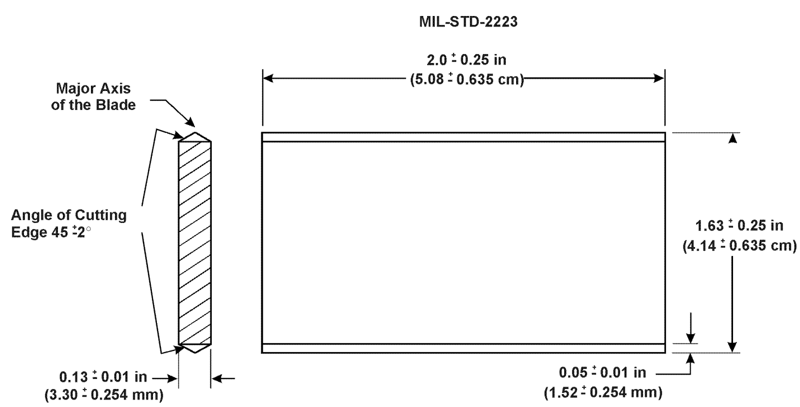


Figure D11-1. Typical abrader blade

D11.2.2 A transparent screen to protect laboratory personnel from molten metals, UV radiation, and other debris that may be ejected from the test specimen.

D11.2.3 An oscillating mechanism to which the abrader blade is connected. The oscillating mechanism will provide a stroke of 1.5 inches (3.81 cm) at a frequency of 0.5 ± 0.05 cycles per second.

D11.2.4 A test fixture that includes a test block to hold the wire at right angles to the abrading blade. The block is made from 6061-T6 aluminum.

D11.2.5 A three-phase Wye connected power supply, grounded at Wye, derived from a rotary machine or solid-state power supply of not less than 20 kVA rating, delivering 208 volts line-to-line at 400 Hz.

D11.2.6 A mechanical stop constructed of stainless steel.

D11.2.7 MS3320-7.5 (7.5 amp) and MS25244-50 (50 amp) protective circuit breakers.

D11.2.8 Variable-load and fixed-load resistors.

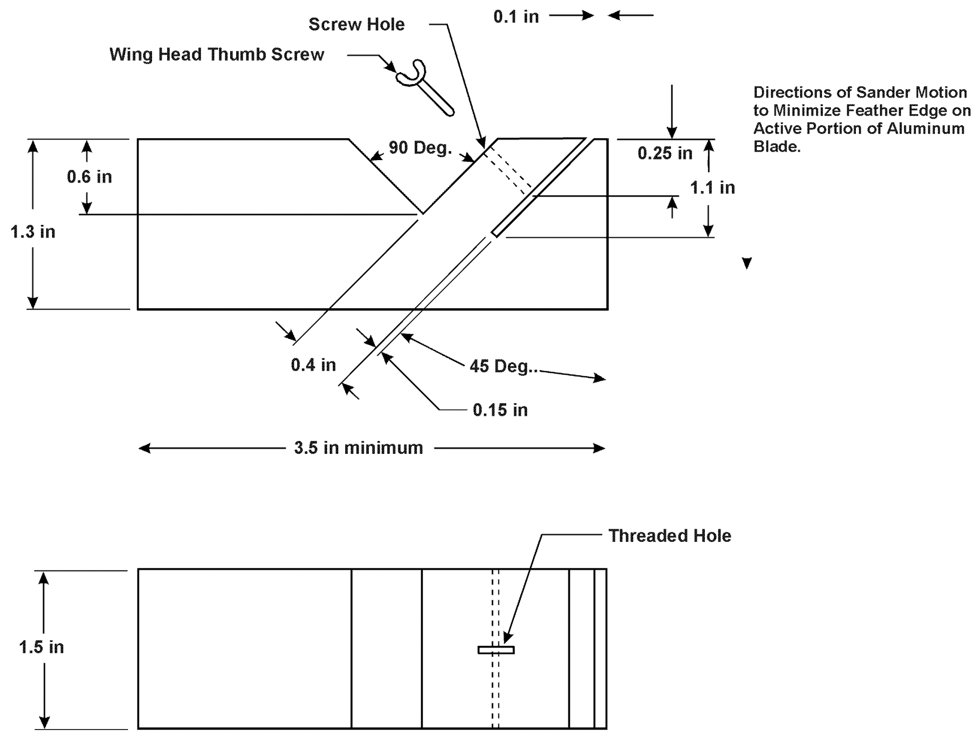


Figure D11-2. Aluminum blade sharpening fixture

D11.2.9 MIL-T-43435 (Type V) lacing tape.

D11.2.10 MS25231 plastic clamps.

D11.3 Test Samples

A test sample will consist of 15 bundles of wire. Each bundle is composed of seven wires and will be of sufficient length, 14 inches (35.6 cm) minimum, to allow the bundle to be installed in the test fixture. A minimum of 122.5 feet (37.3 meters) of wire is required. It is recommended that 20-gauge wire be used for the test.

D11.4 Procedure

D11.4.1 Preparation of Bundles

Conduct a 2500-volt wet dielectric test on 100 percent of the wire in accordance with the wet dielectric test procedure described in MIL-STD-2223, method 3005, before the arc-propagation resistance test is performed. Discard any failed sections of wire. Cut 7 wire segments at least 14 inches (35.6 cm) in length for each of the 15 bundles. Clean the cut wires using a cloth saturated with isopropyl alcohol. Strip both ends of five of the seven-wire segments. Use these stripped ends for making electrical connections. These five-wire segments will be called “active wires.” Form the bundle by laying the seven segments straight and geometrically parallel. Assemble the wires to form the six-around-one configuration shown in figure D11-3. Use MIL-T-43435 lacing tapes to hold the test bundle together. Clean the assembled bundle using a cloth saturated with isopropyl alcohol prior to installation in the test fixture.

D11.4.2 Bundle Installation

A test fixture will be used to hold the wire bundle in place perpendicular to the abrader blade. Details of a suggested test fixture are shown in figure D11-4. Before installation, the wire bundle will be tied with MIL-T-43435 lacing tape at 0.25 inch (0.635 cm) on each side of where the abrader blade is to be applied; then it will be secured to the test fixture. The wire bundle is clamped with MS25281 plastic clamps at two points on the fixture at a minimum distance of 6 inches (15.24 cm). The clamp points are equidistant from the point of application of the abrader. The slide bolt allows the adjusting screw to move the holding plates snugly against the bundle. Ensure that the active wires A1 and B1 are parallel with the top plane of the test fixture and that the passive wires D1 and D2 are in complete contact with the base of the test fixture. The bundle must not be allowed to move while the abrader blade is cutting wires A1 and B1. The test fixture will contain an adjustable mechanical stop, which may be set to allow for various penetration depths of the vibrating blade.

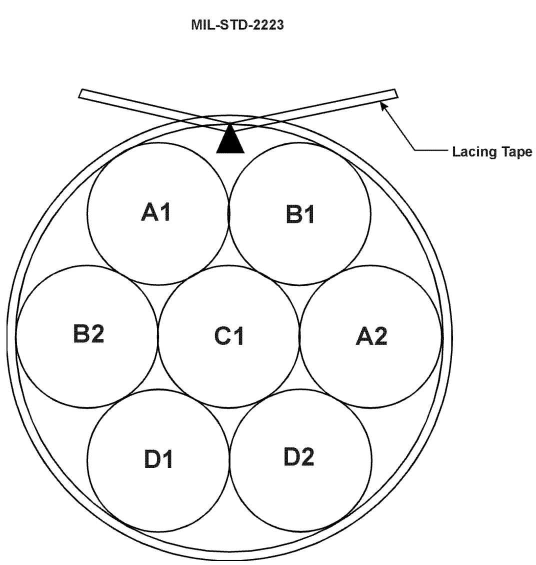


Figure D11-3. Bundle configuration

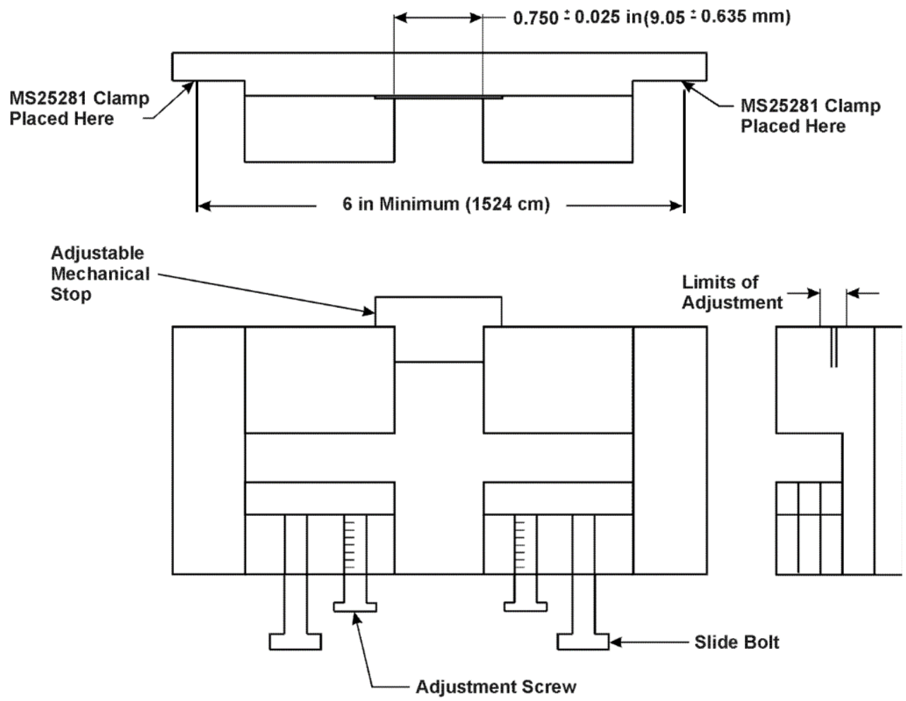


Figure D11-4. Test fixture

D11.4.3 Electrical Connection

Connect the test bundle to the power supply and circuit resistance using the schematic circuit shown in figure D11-5. Connect one end of each active wire to the appropriate phase of the power supply, as shown in table D11-1. Use an MS3320-7.5 (7.5 amp) circuit breaker and a circuit resistance in series with each of the active wires. Use the circuit-resistance values shown in table D11-2. Connect the other end of the five active wires under test to variable resistance loads. Adjust the resistance to limit the current flowing through each wire to 1 ± 0.2 ampere. Protect the test circuits with MS25244-50 (50 amp) circuit breakers connected on the supply side of the test setup. Connect the abrader blade to the neutral of the generator. Connect the generator neutral to ground.

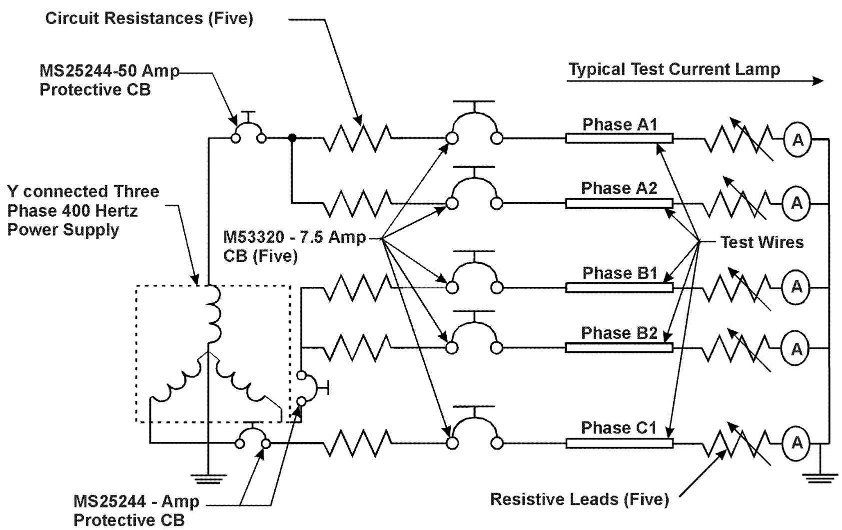


Figure D11-5. Electrical connection

Table D11-1. Electrical connection

Wire Identification	Power Supply	Layer
A1	Phase A	Top
B1	Phase B	Top
C1	Phase C	Middle
A2	Phase A	Middle
B2	Phase B	Middle
D1	None	Lowest
D2	None	Lowest

Table D11-2. Circuit resistance

Test Number	Circuit Resistance (ohm)
1	0.0
2	0.5
3	1.0
4	1.5
5	2.0

D11.4.4 Initiation of Test

Test three bundles for each of the five circuit resistances. Install the oscillating mechanism, which may use a reciprocating arm or vertical and horizontal precision linear ball slides (a suggested ball-slide apparatus is shown in figure D11-6). Adjust the mechanical stop to ensure that the abrader blade penetrates into the A1 and B1 wires at a distance of 0.87 times the radius of the seven wire bundles. Close all circuit breakers. Apply a nominal load of 250 grams (0.551 lb) to the abrader at the point of contact with one wire. Adjust the blade to ensure that the major plane of the blade lies perpendicular to the longitudinal axis of the bundle. Apply the abrader blade on the test bundle. Position the protective screen to shield the operator from ejecting objects and UV radiation. Apply three-phase, 400 Hz power. Actuate the abrader. Allow the abrader blade movement to continue.

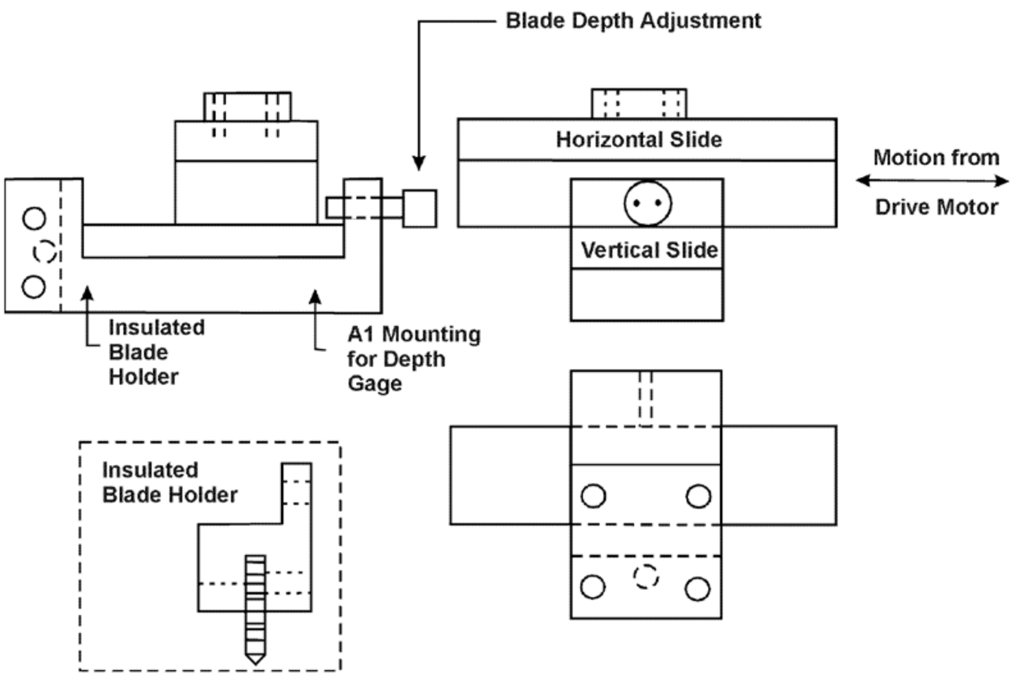


Figure D11-6. Ball-slide blade fixture

D11.5 Results

Use one of the following conditions to conduct and complete the test:

D11.5.1 If the abrader cuts through A1 and B1 wires without tripping phase A1 or phase B1 circuit breakers, stop the abrader movement. Disconnect the power.

D11.5.2 Conduct the 1000 volt wet dielectric test on wires A2, B2, C1, D1, and D2 in accordance with the wet dielectric procedure of MIL-STD 2223, method 3005. Record the number of wires that fail. Measure and record the total length of physical damage to each wire (including phase A1 and B1 wires) in inches.

D11.5.3 If a circuit breaker in any of the phases A2, B2, or C1 trips at any time during the test, stop the abrader and disconnect the power. Perform tests as listed in D11.5.2.

D11.5.4 Stop the abrader if either the phase A1 or phase B1 circuit breaker trips at any time during the test. Disconnect the power and determine if the conductor wires A1 or B1 are open. If both wires are open, conclude the test by performing tests, as listed in D11.5.2. If wire A1 or wire B1 is not open, wait 3 to 4 minutes, reset the circuit breaker, restart the abrader, and then immediately reapply the power. Continue the test until either the phase A1 or phase B1 circuit breaker has tripped a second time, phases A1 and B1 are open, or the blade movement is stopped by the mechanical stop. CAUTION: Do not reset a circuit breaker that trips twice. Perform the tests as listed in D11.5.2. Use a new abrader blade edge for each test bundle if any damage is present or if circuit breakers A1 or B1 trip during the test.

D11.5.5 Circuit breakers should be periodically tested to ensure they still meet the overload requirements of the applicable military specification sheet. Circuit breakers outside their overload trip requirements should be replaced.

D11.6 Information Required in the Individual Specification

Specifications will list the minimum number of wires that must pass the dielectric test after the bundle has been energized and the maximum allowable length of physical damage to the individual wires in the bundle.

Chapter D12
Cotton Swab Test for Thermal Acoustic Insulation Blankets

D12.1 Scope

This industry screening test is intended for use in determining the resistance of thermal acoustic insulation films to flame propagation when tested with alcohol-dipped cotton swabs.

D12.2 Definitions

D12.2.1 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 source.

D12.3 Test Apparatus

D12.3.1 Test Area

Tests will be conducted in a draft-free enclosure. It is suggested that the enclosure be located inside an exhaust hood to facilitate clearing the enclosure of smoke after each test.

D12.3.2 Fuel

Isopropyl alcohol will be used as the flammable solvent.

D12.3.3 Ruler

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

D12.3.4 Cotton Swabs

Two cotton-tipped applicators (equivalent to Q-tips® single-tipped applicators) will be used as the ignition source vehicle. The wooden sticks must be removed before placement on the test samples.

D12.4 Test Specimens

D12.4.1 Specimen Size

The specimen will be a rectangle of at least 16 by 24 inches (406.4 by 609.6 mm).

D12.4.2 Specimen Fabrication

Fabricate a test blanket using insulation batting intended for use in the aircraft and the candidate film cover material. The test blanket must be sealed around the perimeter. This may be accomplished by heat sealing, sewing, or using flame-resistant approved tape.

D12.4.3 Specimen Venting

Make sure that the test blanket is vented. This can be accomplished by puncturing the blanket with a small object, such as a pin.

D12.4.4 Specimen Number

One specimen will be prepared and tested.

D12.4.5 Specimen Thickness

The specimen thickness will be the same as the part qualified for use in the airplane.

D12.5 Test Procedure

D12.5.1 Prop the test blanket against a nonflammable surface in the position shown in figure D12-1. Make sure that the orientation is correct.

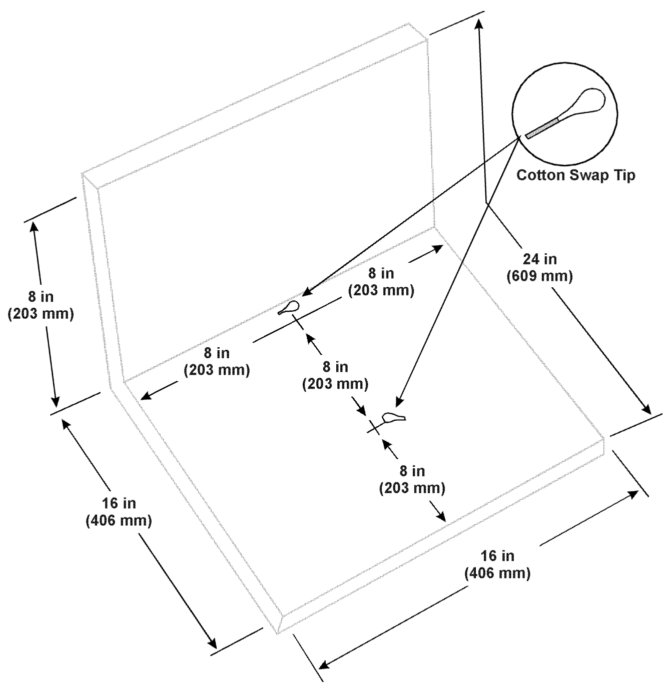


Figure D12-1. Cotton-swab test configuration

D12.5.2 Remove the wooden sticks from the cotton swabs.

D12.5.3 Dip the cotton-tipped ends into the alcohol. Tweezers can be used to accomplish this.

D12.5.4 Ignite the cotton-tipped ends and place one flaming tip in the center of the blanket and one in the crease.

D12.5.5 Allow the cotton-tipped ends to burn to completion or until they self-extinguish.

D12.5.6 Measure the longest burn lengths extending from the center cotton tip and the crease cotton tip.

D12.6 Report

D12.6.1 Identify and describe the test specimen.

D12.6.2 Report each burn length.

D12.6.3 Report any flame spread, if applicable.

D12.7 Requirements

D12.7.1 No burn length shall exceed 8 inches (203.2 mm).

Chapter D13
Test Method to Determine the Flammability and Flame-Propagation Characteristics of Thermal/Acoustic Insulation Materials

D13.1 Scope

D13.1.1 Applicability

This test method can be used to evaluate the flammability and flame-propagation characteristics of thermal/acoustic insulation when exposed to both a radiant heat source and a flame.

D13.2 Definitions

D13.2.1 Flame Propagation

Flame propagation is the furthest distance of the propagation of visible flame toward the far end of the test specimen, measured from the midpoint of the ignition source flame. Measure this distance after initially applying the ignition source and before all flame on the test specimen is extinguished. The measurement is not a determination of burn length made after the test.

D13.2.2 Radiant Heat Source

Radiant heat source is an electric or air propane panel.

D13.2.3 Thermal/Acoustic Insulation

Thermal/acoustic insulation is a material or system of materials used to provide thermal or acoustic protection. Examples include fiberglass or other batting material encapsulated by a film covering and foam.

D13.2.4 Zero Point

Zero point is the point of application of the pilot burner to the test specimen.

D13.3 Test Apparatus

D13.3.1 Radiant Panel Test Chamber.

Conduct tests in a radiant panel test chamber (see figure D13-1). Place the test chamber under an exhaust hood to facilitate clearing the chamber of smoke after each test.

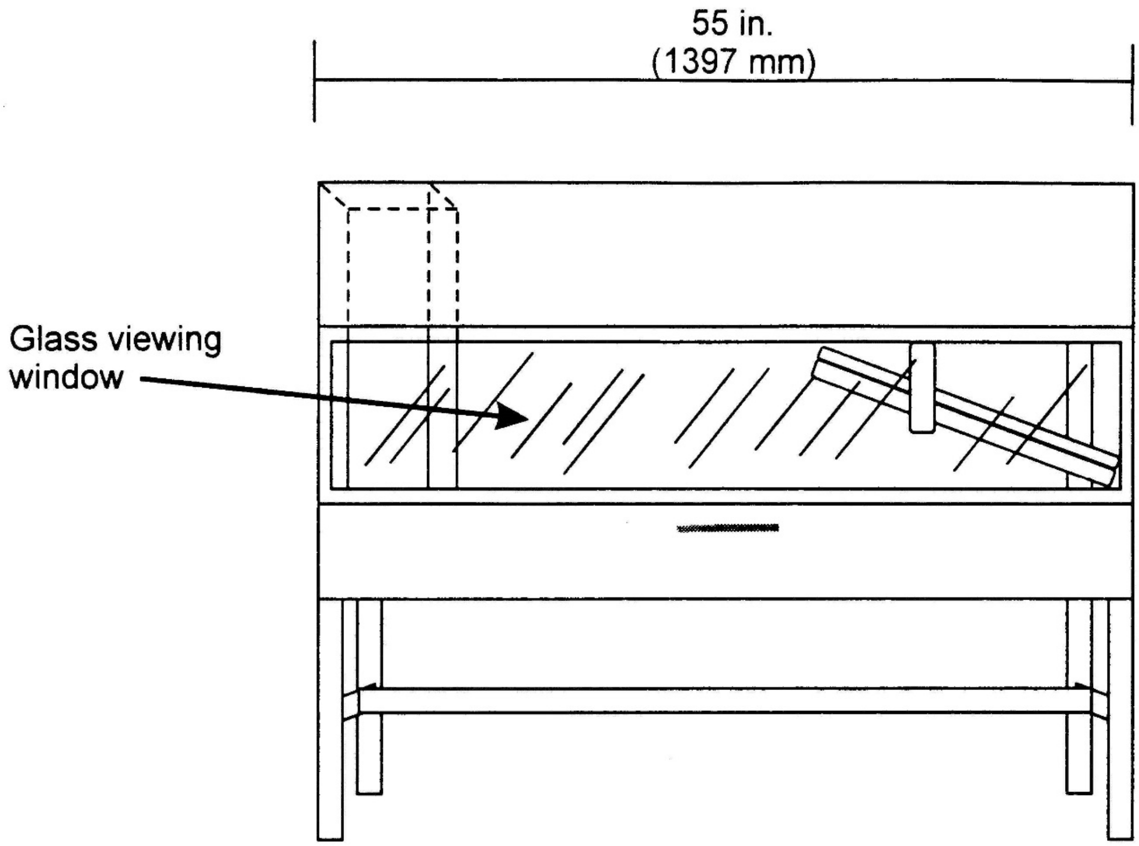


Figure D13-1. Radiant panel test chamber

D13.3.1.1 Enclosure

The radiant panel test chamber must be an enclosure 55 inches (1397 mm) long by 19.5 (495 mm) deep by 28–30 inches (710–762 mm) high, maximum, above the test specimen.

D13.3.1.2 Insulation

Insulate the sides, ends, and top with a fibrous ceramic insulation, such as Kaowool M™ board.

D13.3.1.3 Viewing Window

On the front side, provide a 52- by 12-inch (1321 by 305 mm), draft-free, high-temperature glass window for viewing the sample during testing.

D13.3.1.4 Access Door

Place a door below the window to provide access to the movable specimen platform holder. The bottom of the test chamber must be a sliding steel platform that has provision for securing the test specimen holder in a fixed and level position.

D13.3.1.5 Internal Chimney

The chamber must have an internal chimney with exterior dimensions of 5.1 inches (129 mm) wide by 16.2 inches (411 mm) deep by 13 inches (330 mm) high at the opposite end of the chamber from the radiant energy source. The interior dimensions must be 4.5 inches (114 mm) wide by 15.6 inches (395 mm) deep. The chimney must extend to the top of the chamber (see figure D13-2).

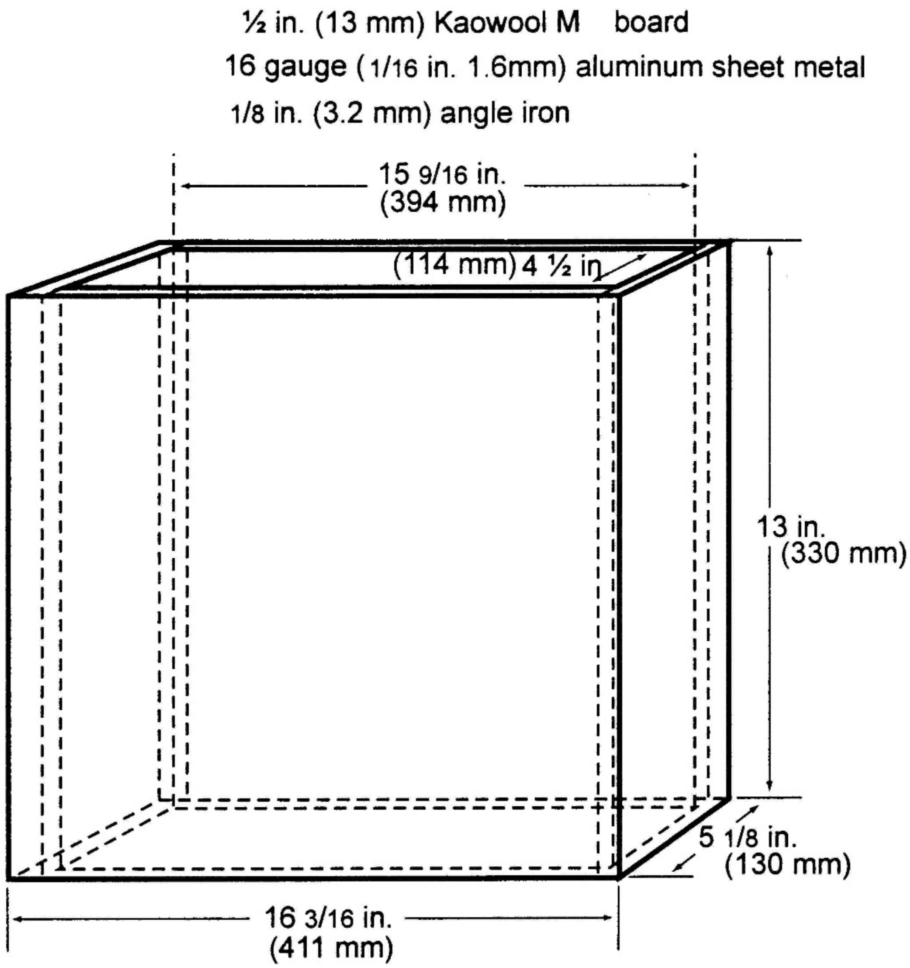


Figure D13-2. Internal chimney

D13.3.2 Radiant Heat Source

Mount the radiant heat energy source in a cast iron frame or equivalent.

D13.3.2.1 Electric Radiant Panel

An electric panel must have six 3-inch wide emitter strips. The emitter strips must be perpendicular to the length of the panel. The panel must have a radiation surface of 12.875 by 18.5 inches (327 by 470 mm). The panel must be capable of operating at temperatures up to 1300°F (704°C) (see figure D13-3).

D13.3.2.1.1 Electric Power

The radiant panel must be three-phase and operate at 208 volts. A single-phase, 240 volt panel is also acceptable. Use a solid-state power controller and microprocessor-based controller to set the electric panel operating parameters.

D13.3.2.2 Gas Radiant Panel

An air propane panel must be made of a porous refractory material and have a radiation surface of 12 by 18 inches (305 by 457 mm). The panel must be capable of operating at temperatures up to 1500°F (816°C) (see figure D13-4).

D13.3.2.2.1 Fuel Source

Use propane (liquid petroleum gas—2.1 UN 1075) for the radiant panel fuel.

D13.3.2.2.2 Fuel System

The panel fuel system must consist of a Venturi-type aspirator for mixing gas and air at approximately atmospheric pressure.

D13.3.2.2.3 Fuel-Flow Monitoring

Provide suitable instrumentation for monitoring and controlling the flow of fuel and air to the panel. Include an airflow gauge, an airflow regulator, and a gas pressure gauge.

D13.3.2.3 Radiant Panel Placement

Mount the panel in the chamber at 30 degrees to the horizontal specimen plane, and 7.5 inches above the zero point of the specimen.

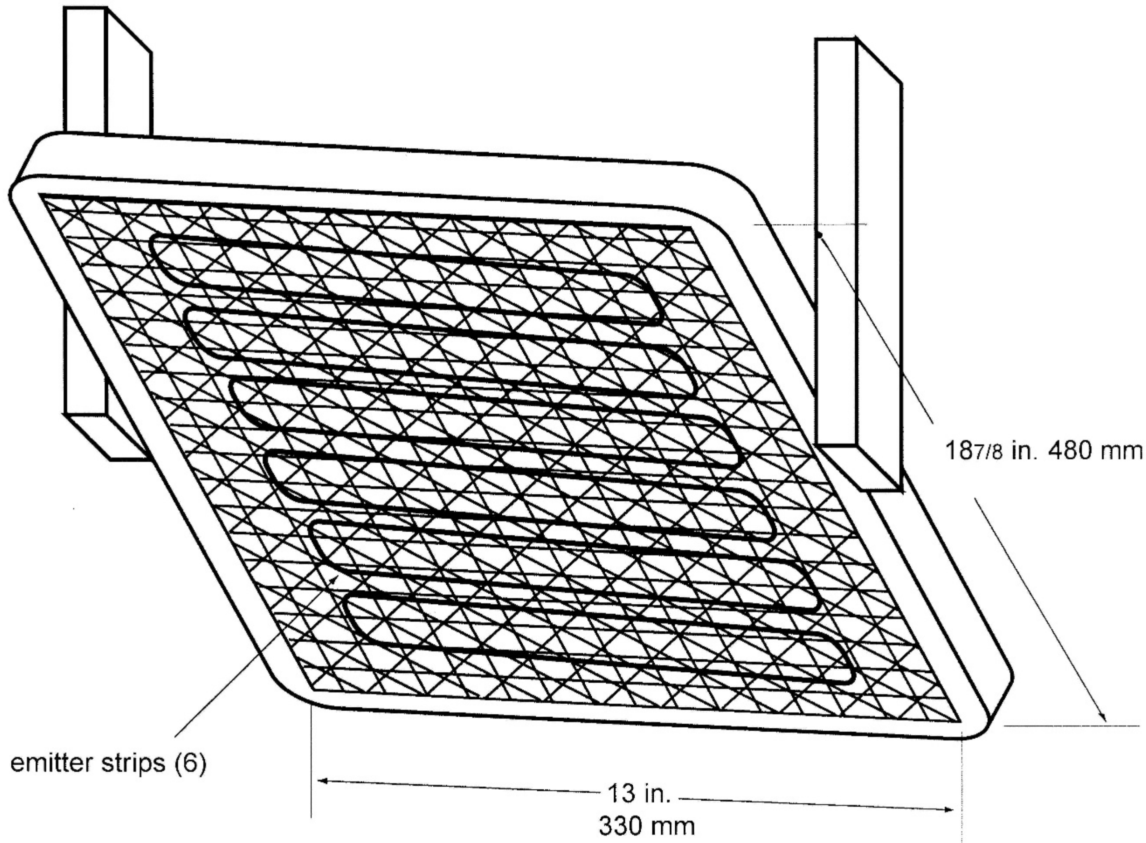


Figure D13-3. Electric panel

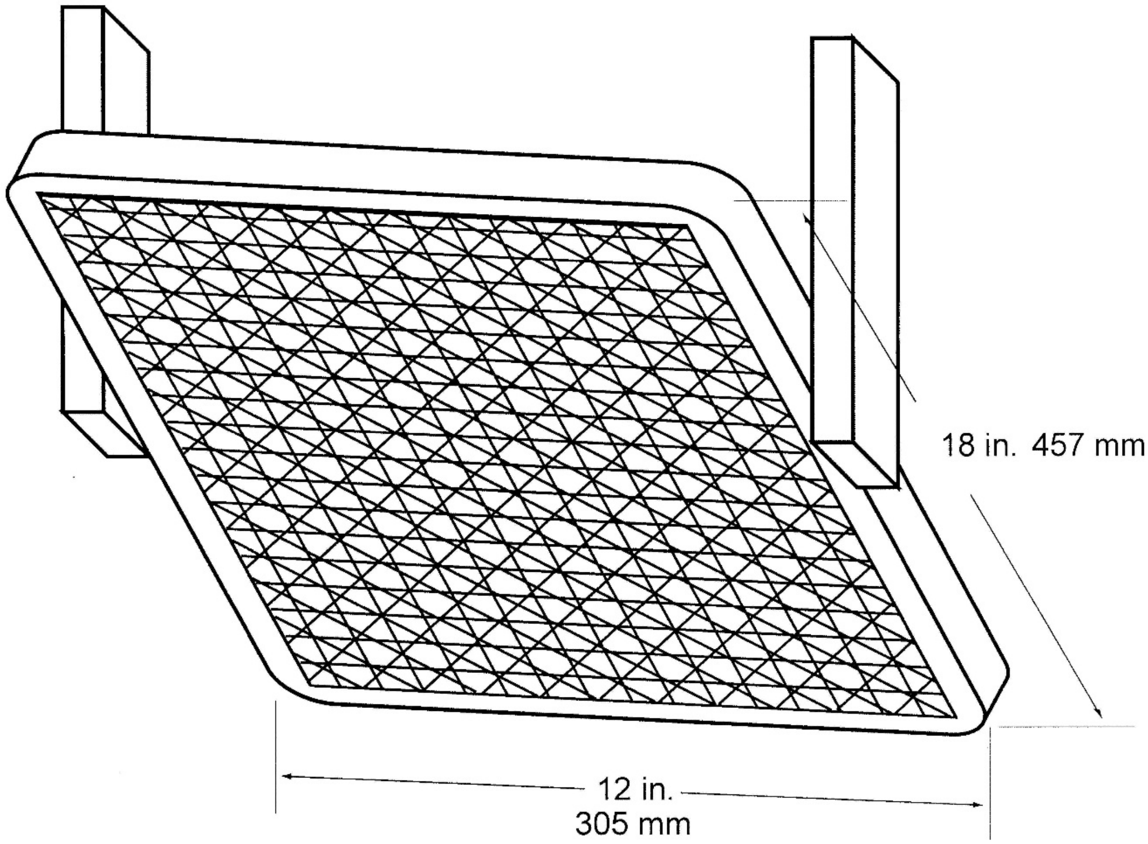


Figure D13-4. Air propane radiant panel

D13.3.3 Specimen Holding System

D13.3.3.1 Sliding Platform

The sliding platform serves as the housing for test specimen placement. Brackets may be attached (via wing nuts) to the top lip of the platform to accommodate various thicknesses of test specimens.

D13.3.3.2 Backer Board

Place the test specimens on a sheet of Kaowool M board or 1260 Standard Board (manufactured by Thermal Ceramics and available in Europe) or equivalent, either resting on the bottom lip of the sliding platform or on the base of the brackets. It may be necessary to use multiple sheets of material based on the thickness of the test specimen (to meet the sample height requirement). Typically, these noncombustible sheets of material are available in 0.25-inch (6 mm) thicknesses (see figure D13-5). A sliding platform that is deeper than the 2-inch (50.8 mm) platform shown in figure D13-5 is also acceptable if the sample height requirement is met.

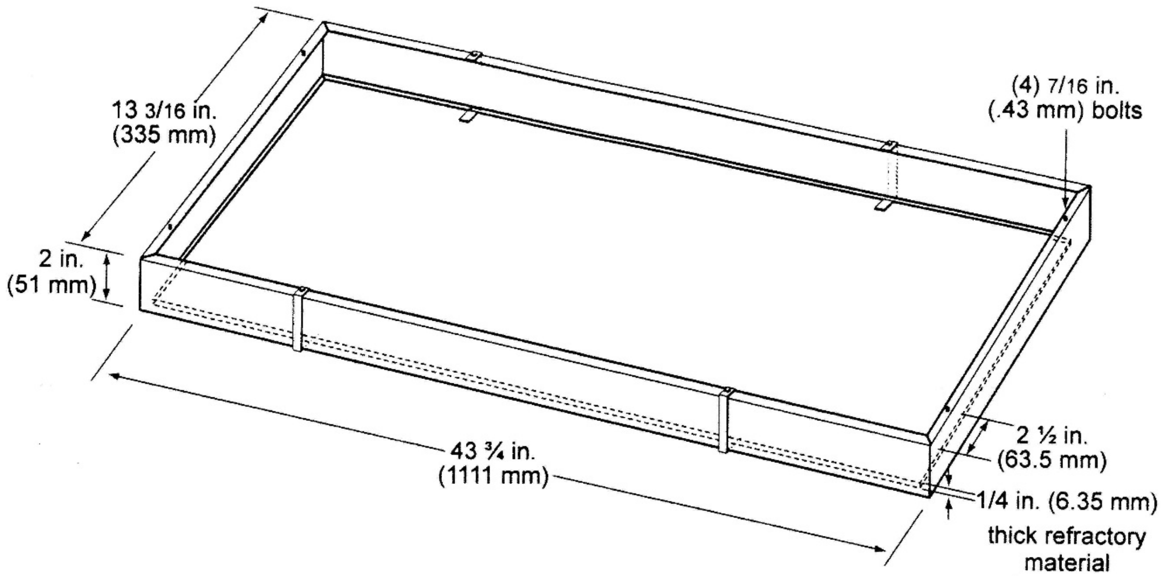


Figure D13-5. Sliding platform

D13.3.3.3 Heat Retainer

Attach a 0.50-inch (13 mm) piece of Kaowool M board or other high-temperature material measuring 41.5 by 8.25 inches (1054 by 210 mm) to the back of the platform. This board serves as a heat retainer and protects the test specimen from excessive preheating. The height of this board must not impede the sliding platform movement (in and out of the test chamber). A retainer board is not necessary if the platform has been fabricated such that the back side of the platform is high enough to prevent excess preheating of the specimen when the sliding platform is out.

D13.3.3.4 Retaining Frame

Place the test specimen horizontally on the noncombustible board(s). Place a steel retaining/securing frame fabricated of mild steel, having a thickness of 0.125 inch (3.2 mm) and overall dimensions of 23 by 13.125 inches (584 by 333 mm) with a specimen opening of 19 by 10.75 inches (483 by 273 mm) over the test specimen. The front, back, and right portions of the top flange of the frame must rest on the top of the sliding platform, and the bottom flanges must pinch all four sides of the test specimen. The right bottom flange must be flush with the sliding platform (see figure D13-6).

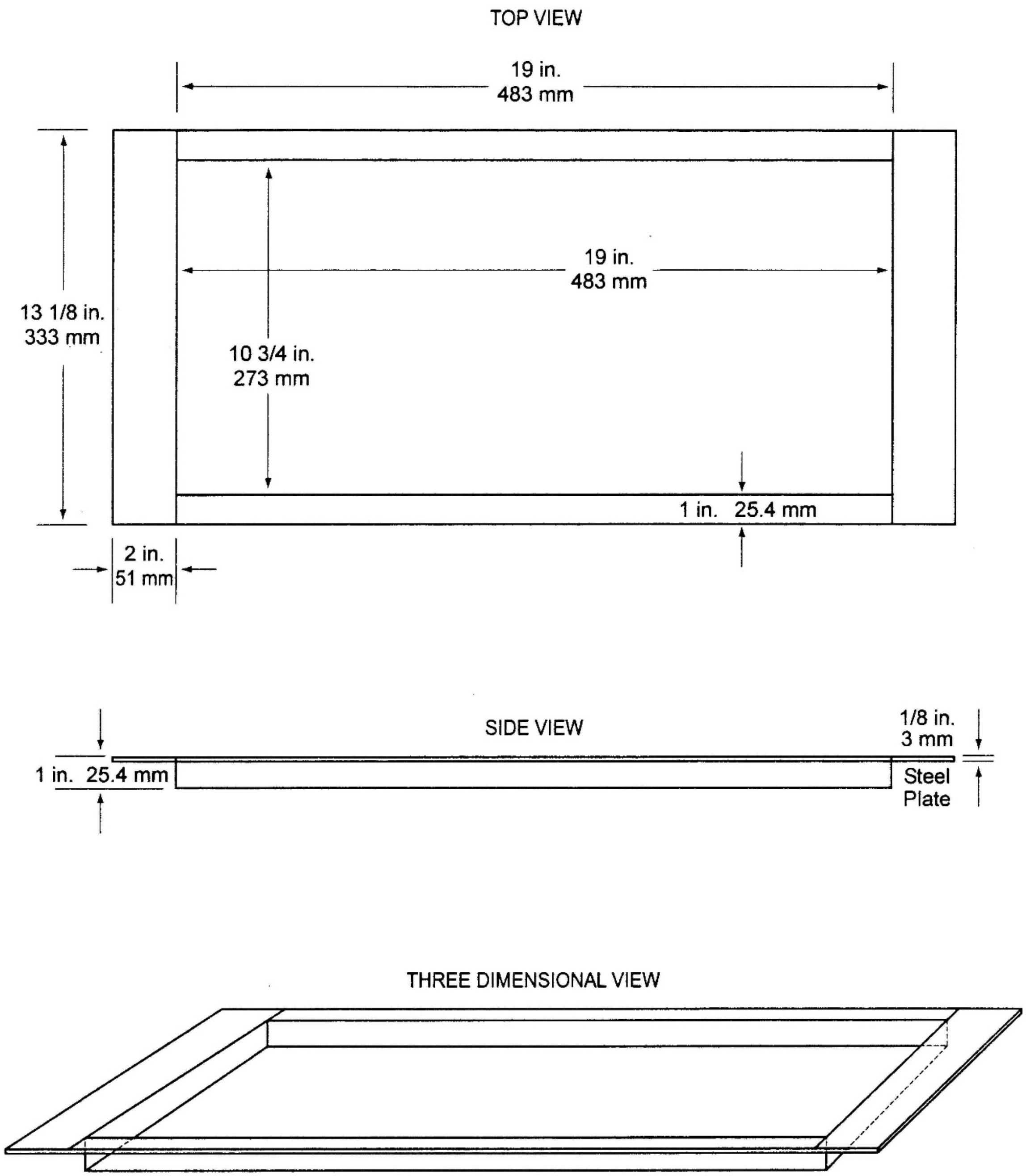


Figure D13-6. Three views of retaining frame

D13.3.4 Pilot Burner

The pilot burner used to ignite the specimen must be a Bernzomatic™ commercial propane Venturi torch with an axially symmetric burner tip and a propane supply tube with an orifice diameter of 0.006 inch (0.15 mm). The length of the burner tube must be 2.875 inches (71 mm) (see figure D13-7).

D13.3.4.1 Flame-Length Adjustment

The propane flow must be adjusted via gas pressure through an inline regulator to produce a blue inner cone length of 0.75 inch (19 mm).

D13.3.4.2 Flame Length Guide

A 0.75-inch (19 mm) guide such as a thin strip of metal may be soldered to the top of the burner to aid in setting the flame height. The overall flame length must be approximately 5 inches long (127 mm).

D13.3.4.3 Pilot Burner Standby Position

Provide a way to move the burner out of the ignition position so that the flame is horizontal and at least 2 inches (50 mm) above the specimen plane.

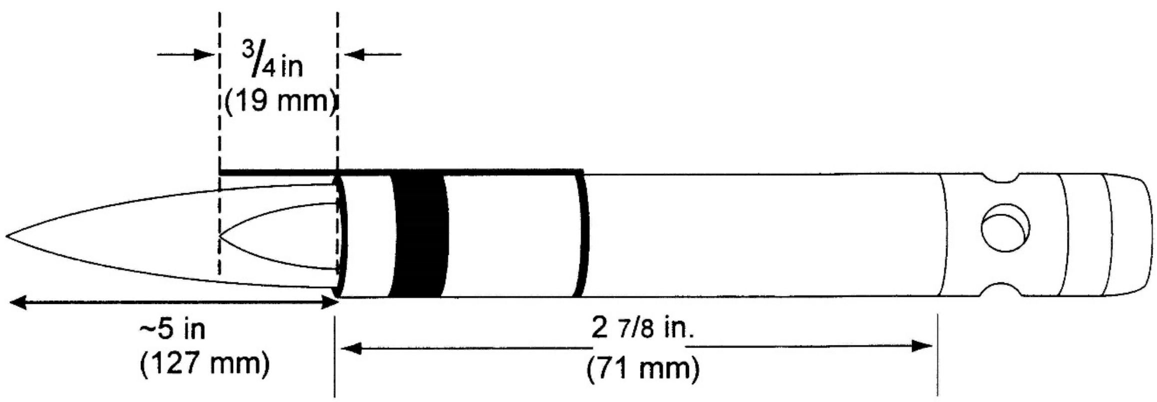


Figure D13-7. Propane pilot burner

D13.3.5 Thermocouples

Install a 24-American Wire Gauge (AWG) type K (chromel-alumel) thermocouple in the test chamber for temperature monitoring. Insert it into the chamber through a small hole drilled through the back of the chamber. Place the thermocouple so that it extends 11 inches (279 mm) out from the back of the chamber wall, 11.5 inches (292 mm) from the right side of the chamber wall, and 2 inches (51mm) below the radiant panel. The use of other thermocouples is optional.

D13.3.6 Calorimeter

The calorimeter must be a 1-inch cylindrical, water-cooled, total heat-flux density, foil-type Gardon gauge that has a range of 0 to 5 BTU/ft^2-second (0 to 5.7 W/cm^2).

D13.3.7 Calorimeter Calibration Specification and Procedure

D13.3.7.1 Calorimeter specification

(A) Foil diameter must be 0.25 ± 0.005 inch (6.35 ± 0.13 mm).

(B) Foil thickness must be 0.0005 ± 0.0001 inch (0.013 ± 0.0025 mm).

(C) Foil material must be thermocouple grade Constantan.

(D) Temperature measurement must be a Copper Constantan thermocouple.

(E) The copper center wire diameter must be 0.0005 inch (0.013 mm).

(F) The entire face of the calorimeter must be lightly coated with “Black Velvet” paint having an emissivity of 96 or greater.

D13.3.7.2 Calorimeter calibration

(A) The calibration method must be by comparison to a similar standardized transducer.

(B) The standardized transducer must meet the specifications given in paragraph D13.3.6 of this chapter.

(C) Calibrate the standard transducer against a primary standard traceable to the National Institute of Standards and Technology (NIST).

(D) The method of transfer must be a heated graphite plate.

(E) The graphite plate must be electrically heated, have a clear surface area on each side of the plate of at least 2 by 2 inches (51 by 51 mm), and be 0.125 inch ±0.0625 inch thick (3.2 ± 1.6 mm).

(F) Center the two transducers on opposite sides of the plates at equal distances from the plate.

(G) The distance of the calorimeter to the plate must be no less than 0.0625 inch (1.6 mm), and no greater than 0.375 inch (9.5 mm).

(H) The range used in calibration must be at least 0–3.5 BTUs/ft^2 second (0–3.9 W/cm^2) and no greater than 0–5.7 BTUs/ft^2 second (0–6.4 W/cm^2).

(I) The recording device used must record the two transducers simultaneously or at least within 1⁄10 of a second of each other.

D13.3.8 Calorimeter Fixture

With the sliding platform pulled out of the chamber, install the calorimeter holding frame and place a sheet of noncombustible material in the bottom of the sliding platform adjacent to the holding frame. This will prevent heat losses during calibration. The frame must be 13.125 inches (333 mm) deep (front to back) by 8 inches (203 mm) wide and must rest on the top of the sliding platform. It must be fabricated of 0.125-inch (3.2 mm) flat stock steel and have an opening that accommodates a 1⁄2 inch--thick (12.7 mm) piece of refractory board, which is level with the top of the sliding platform. The board must have three 1-inch (25.4 mm) diameter holes drilled through the board for calorimeter insertion. The distance to the radiant panel surface from the centerline of the first hole ("zero" position) must be 7.5 ± 0.125 inches (191 ± 3 mm). The distance between the centerline of the first hole to the centerline of the second hole must be 2 inches (51 mm). It must also be the same distance from the centerline of the second hole to the centerline of the third hole (see figure D13-8). A calorimeter holding frame that differs in construction is acceptable if the height from the centerline of the first hole to the radiant panel and the distance between holes is the same as described in this paragraph.

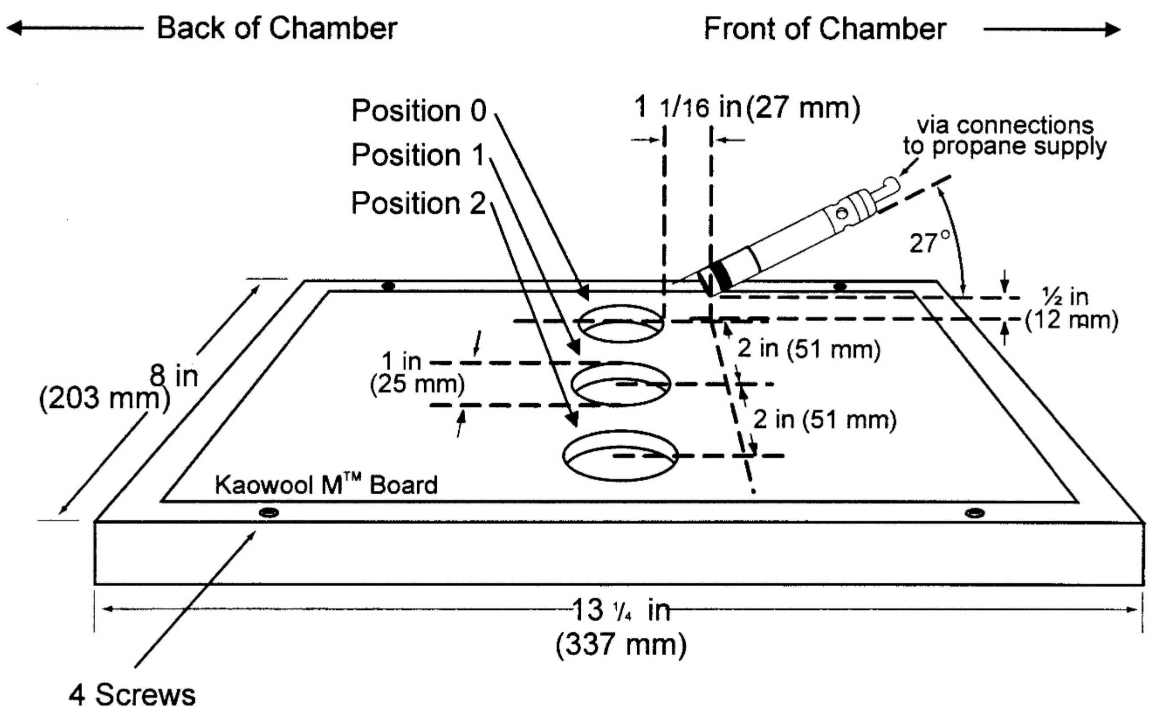


Figure D13-8. Calorimeter holding frame

D13.3.9 Instrumentation

Provide a calibrated recording device with an appropriate range or a computerized data-acquisition system to measure and record the outputs of the calorimeter and the thermocouple. The data-acquisition system must be capable of recording the calorimeter output every second during calibration.

D13.3.10 Timing device

Provide a stopwatch or other device, accurate to ± 1 sec/hr, to measure the time of application of the pilot burner flame.

D13.4 Test Specimens

D13.4.1 Specimen preparation

Prepare and test a minimum of three test specimens. If an oriented film cover material is used, prepare and test both the warp and fill directions.

D13.4.2 Construction

Test specimens must include all materials used in construction of the insulation, including batting, film, scrim, and tape. Cut a piece of core material, such as foam or fiberglass, and cut a piece of film cover material (if used) large enough to cover the core material. Heat sealing is the preferred method of preparing fiberglass samples because they can be made without compressing the fiberglass (box sample). Cover materials that are not heat sealable will have enough excess material to be drawn down the sides without compressing the core material. The fastening means should be as continuous as possible along the length of the seams. The specimen thickness must be of the same thickness as installed in the airplane.

D13.4.3 Specimen Dimensions

To facilitate proper placement of specimens in the sliding platform housing, cut non-rigid core materials, such as fiberglass, 12.5 inches (318 mm) wide by 23 inches (584 mm) long. Cut rigid materials, such as foam, 11.5 ± 0.25 inches (292 mm ± 6 mm) wide by 23 inches (584 mm) long to fit properly in the sliding platform housing and provide a flat, exposed surface equal to the opening in the housing.

D13.5 Specimen Conditioning

Condition the test specimens at 70° ± 5°F (21° ± 2°C) and 55% ± 10% relative humidity, for a minimum of 24 hours prior to testing.

D13.6 Apparatus Calibration

D13.6.1 Position Calorimeter Holding Frame

Install the calorimeter holding frame with the sliding platform out of the chamber. Push the platform back into the chamber and insert the calorimeter into the first hole (“zero” position). (See figure D13-8.) Close the bottom door located below the sliding platform. The distance from the centerline of the calorimeter to the radiant panel surface at this point must be 7.5 inches ± 0.125 inches (191 mm ± 3). Prior to igniting the radiant panel, ensure that the calorimeter face is clean and that that there is water running through the calorimeter.

D13.6.2 Ignite Panel

Adjust the fuel/air mixture to achieve 1.5 BTUs/ft^2-second ±5% (1.7 W/cm^2 ± 5%) at the “zero” position. If using an electric panel, set the power controller to achieve the proper heat flux. Allow the unit to reach steady state (this may take up to 1 hour). The pilot burner must be off and in the down position during this time.

D13.6.3 Check Heat-Flux Profile

After steady-state conditions have been reached, move the calorimeter 2 inches (51 mm) from the “zero” position (first hole) to position 1 and record the heat flux. Move the calorimeter to position 2 and record the heat flux. Allow enough time at each position for the calorimeter to stabilize. Table D13-1 depicts typical calibration values at the three positions.

Table D13-1. Calibration table

Position	BTU/ft^2 sec	Watt/cm^2
“Zero” Position	1.5	1.7
Position 1	1.51–1.50–1.49	1.71–1.70–1.69
Position 2	1.43–1.44	1.62–1.63

D13.6.4 Remove Calorimeter and Holder

Open the bottom door and remove the calorimeter and holder fixture. Use caution because the fixture is very hot.

D13.7 Test Procedure

D13.7.1 Ignite the Pilot Burner

After igniting the pilot burner, ensure that it is at least 2 inches (51 mm) above the top of the platform. The burner must not contact the specimen until the test begins.

D13.7.2 Install Test Specimen

Place the test specimen in the sliding platform holder. Ensure that the test-sample surface is level with the top of the platform. At “zero” position, the specimen surface must be 7.5 inches ± 0.125 inch (191 mm ± 3) below the radiant panel.

D13.7.3 Install Retaining Frame

Place the retaining/securing frame over the test specimen. Because of compression, it may be necessary to adjust the sample up or down to maintain the distance from the sample to the radiant panel (7.5 ± 0.125 inches [191 ± 3 mm] at “zero” position). With film/fiberglass assemblies, it is critical to make a slit in the film cover to purge any air inside. This allows the operator to maintain the proper test specimen position (level with the top of the platform) and allows ventilation of gases during testing. A longitudinal slit, approximately 2 inches (51 mm) in length, must be centered 3 ± 0.50 inches (76 ± 13 mm) from the left flange of the securing frame. A utility knife is acceptable for slitting the film cover.

D13.7.4 Insert Sample

Immediately push the sliding platform into the chamber and close the bottom door.

D13.7.5 Apply Pilot Burner

Bring the pilot burner flame into contact with the center of the specimen at the “zero” position and simultaneously start the timer. The pilot burner must be at a 27-degree angle with the sample and be approximately 0.50 inch (12 mm) above the sample (see figure D13-8). A stop, as shown in figure D13-9, allows the operator to position the burner correctly each time.

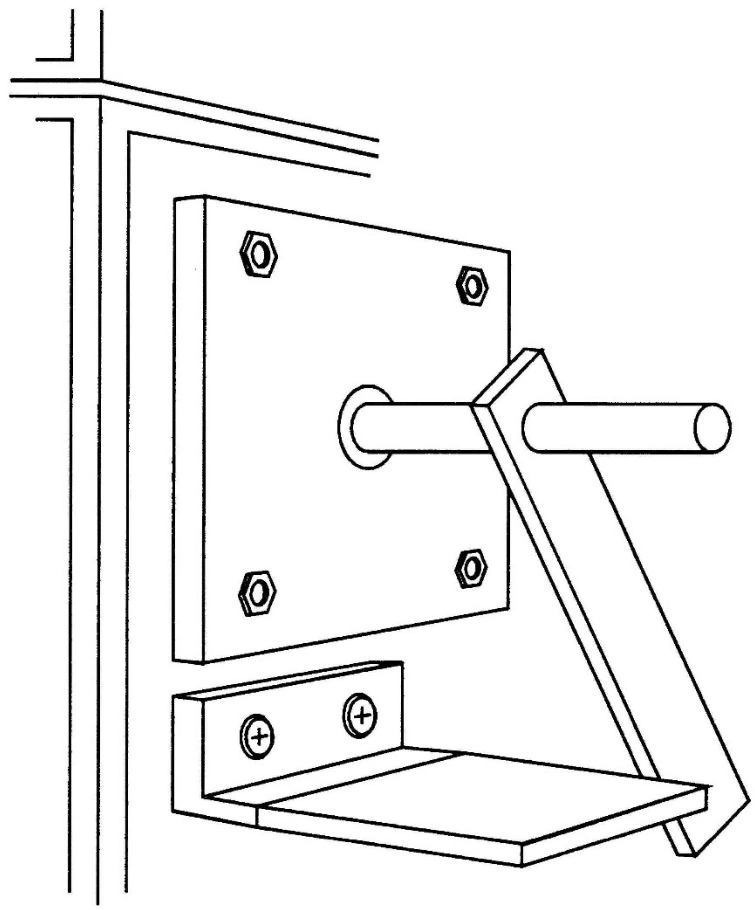


Figure D13-9. Propane burner stop

D13.7.6 Remove Pilot Burner

Leave the burner in position for 15 seconds, and then remove to a position at least 2 inches (51 mm) above the specimen.

D13.8 Report

D13.8.1 Identify and describe the test specimen.

D13.8.2 Report any shrinkage or melting of the test specimen.

D13.8.3 Report the flame propagation distance.

If this distance is less than 2 inches, report this as a pass (no measurement required).

D13.8.4 Report the after-flame time.

D13.9 Requirements

D13.9.1 There must be no flame propagation beyond 2 inches (51 mm) to the left of the centerline of the pilot flame application.

D13.9.2 The flame time after removal of the pilot burner may not exceed 3 seconds on any specimen.

Chapter D14
Test Method to Determine the Burnthrough Resistance of Thermal/Acoustic Insulation Materials

D14.1 Scope

D14.1 Applicability

This test method can be used to evaluate the burnthrough resistance characteristics of aircraft thermal/acoustic insulation materials when exposed to a high-intensity open flame.

D14.2 Definitions

D14.2.1 Burnthrough Time

Burnthrough time means the time, in seconds, for the burner flame to penetrate the test specimen, and/or the time required for the heat flux to reach 2.0 Btu/ft^{2}sec (2.27 W/cm^2) on the inboard side at a distance of 12 inches (30.5 cm) from the front surface of the insulation blanket test frame, whichever is sooner. The burnthrough time is measured at the inboard side of each of the insulation blanket specimens.

D14.2.2 Insulation Blanket Specimen

Insulation blanket specimen means one of two specimens positioned in either side of the test rig, at an angle of 30 degrees with respect to vertical.

D14.2.3 Specimen Set

Specimen set means two insulation blanket specimens. Both specimens must represent the same production insulation blanket construction and materials, proportioned to correspond to the specimen size.

D14.3 Apparatus

D14.3.1 Test Apparatus

The arrangement of the test apparatus is shown in figures D14-1 and D14-2, and must include the capability of swinging the burner away from the test specimen during warmup.

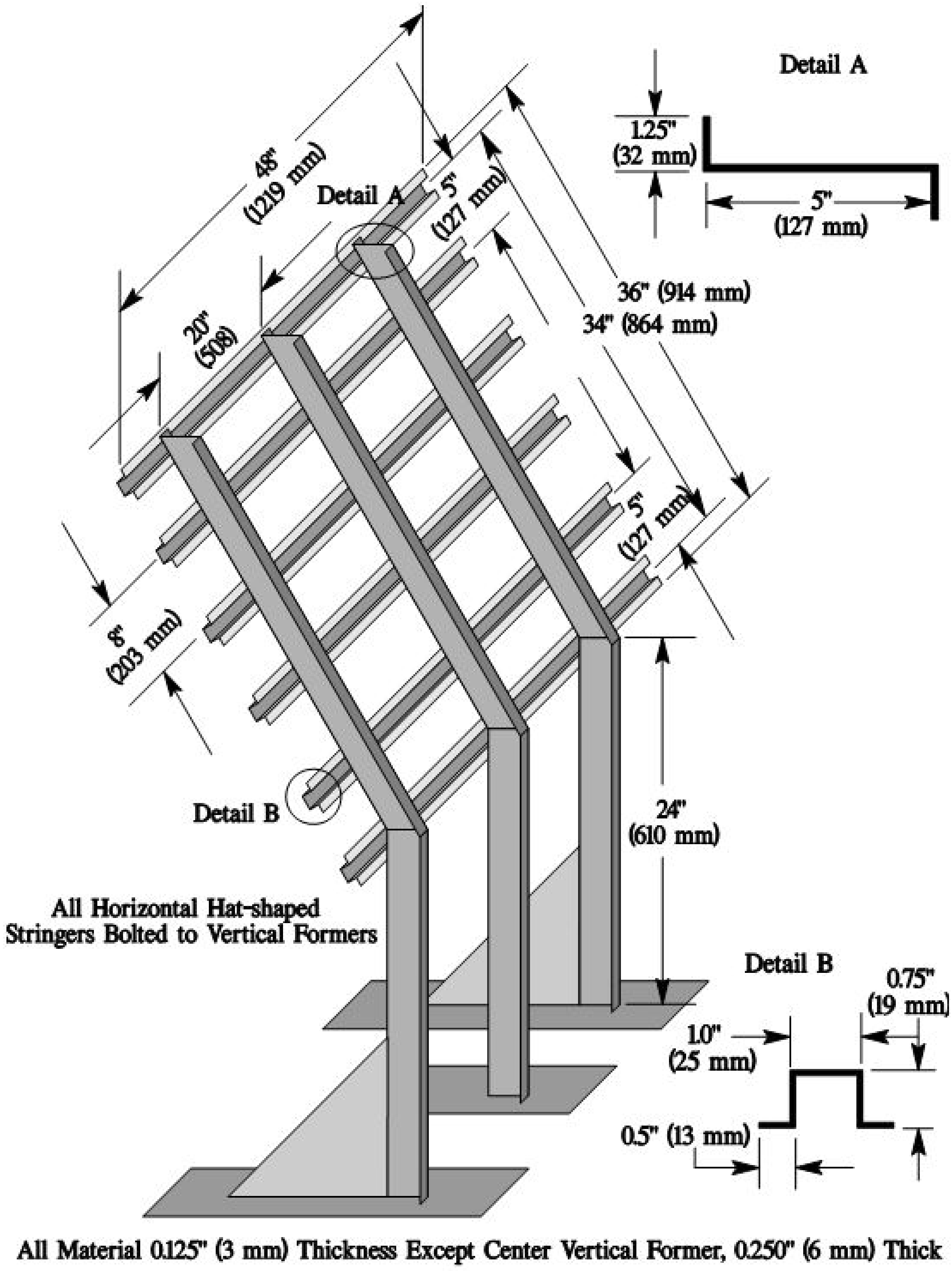


Figure D14-1. Burnthrough test apparatus specimen holder

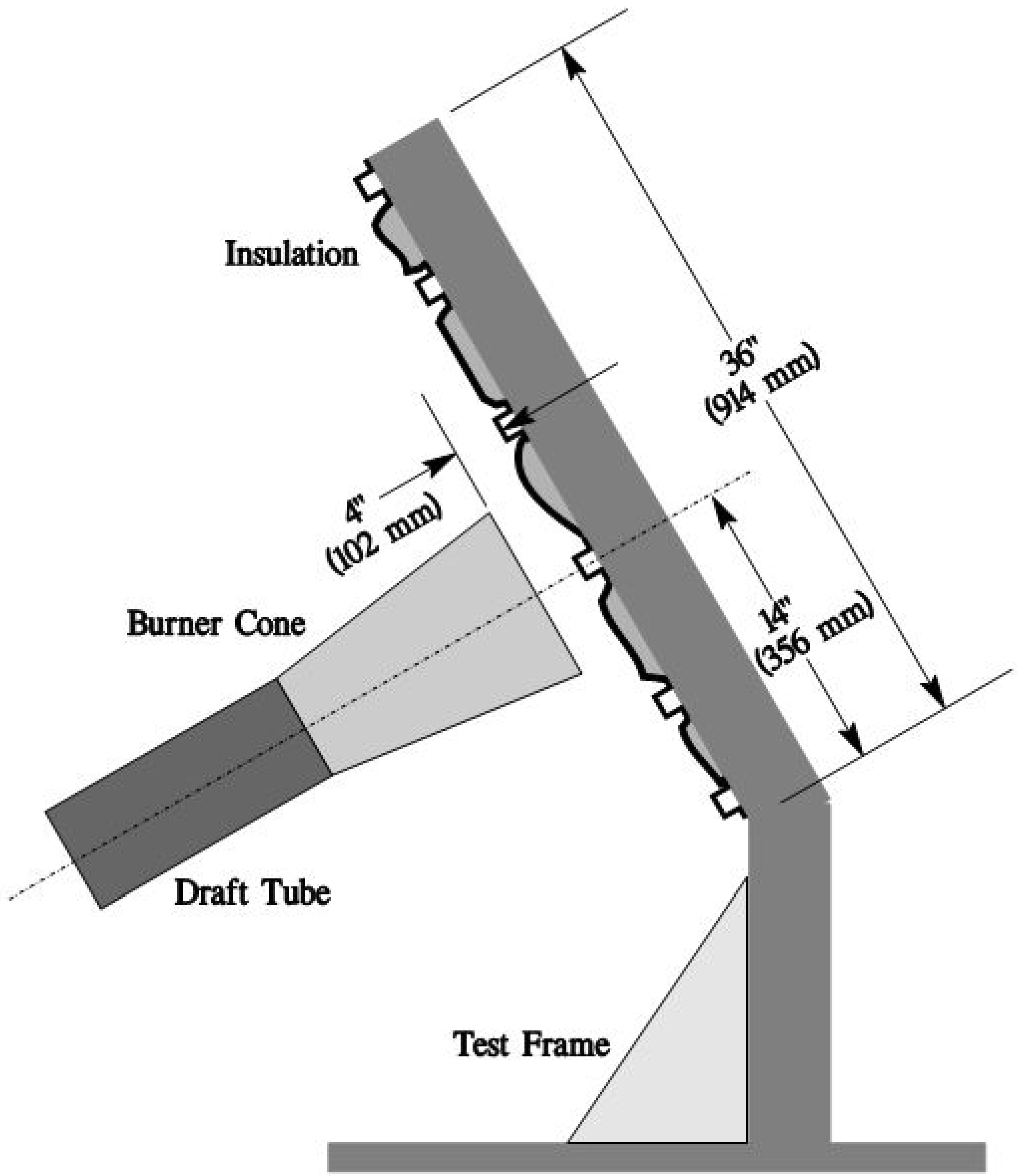


Figure D14-2. Burnthrough test apparatus specimen holder

D14.3.2 Test Burner

The test burner must be a modified gun-type, such as the Park Model DPL 3400. Flame characteristics are highly dependent on actual burner setup. Parameters such as fuel pressure, nozzle depth, stator position, and intake airflow must be properly adjusted to achieve the correct flame output.

D14.3.2.1 Fuel Nozzle

A nozzle must maintain the fuel pressure to yield a nominal 6.0 gal/hr (0.378 L/min) fuel flow. A Monarch-manufactured 80 degree PL (hollow cone) nozzle nominally rated at 6.0 gal/hr at 100 lb/in^2 (0.71 MPa) delivers a proper spray pattern.

D14.3.2.2 Fuel Rail

The fuel rail must be adjusted to position the fuel nozzle at a depth of 0.3125 inch (8 mm) from the end plane of the exit stator, which must be mounted in the end of the draft tube.

D14.3.2.3 Internal Stator

The internal stator, located in the middle of the draft tube, must be positioned at a depth of 3.75 inches (95 mm) from the tip of the fuel nozzle. The stator must also be positioned so the integral igniters are located at an angle midway between the 10 and 11 o'clock position, when viewed looking into the draft tube. Minor deviations to the igniter angle are acceptable if the temperature and heat-flux requirements conform to the requirements of paragraphs D14.6.4 and D14.6.5 of this appendix.

D14.3.2.4 Blower Fan

The cylindrical blower fan used to pump air through the burner must measure 5.25 inches (133 mm) in diameter by 3.5 inches (89 mm) in width.

D14.3.2.5 Burner Cone

Install a 12 ± 0.125-inch (305 ± 3 mm) burner extension cone at the end of the draft tube. The cone must have an opening 6 ± 0.125-inches (152 ± 3 mm) high and 11 ± 0.125-inches (280 ± 3 mm) wide (see figure D14-3).

D14.3.2.6 Fuel

Use JP-8, Jet A, or their international equivalent, at a flow rate of 6.0 ± 0.2 gal/hr (0.378 ± 0.0126 L/min). If this fuel is unavailable, ASTM K2 fuel (Number 2 grade kerosene) or ASTM D2 fuel (Number 2 grade fuel oil or Number 2 diesel fuel) are acceptable if the nominal fuel flow rate, temperature, and heat-flux measurements conform to the requirements of paragraphs D14.6.4 and D14.6.5 of this appendix.

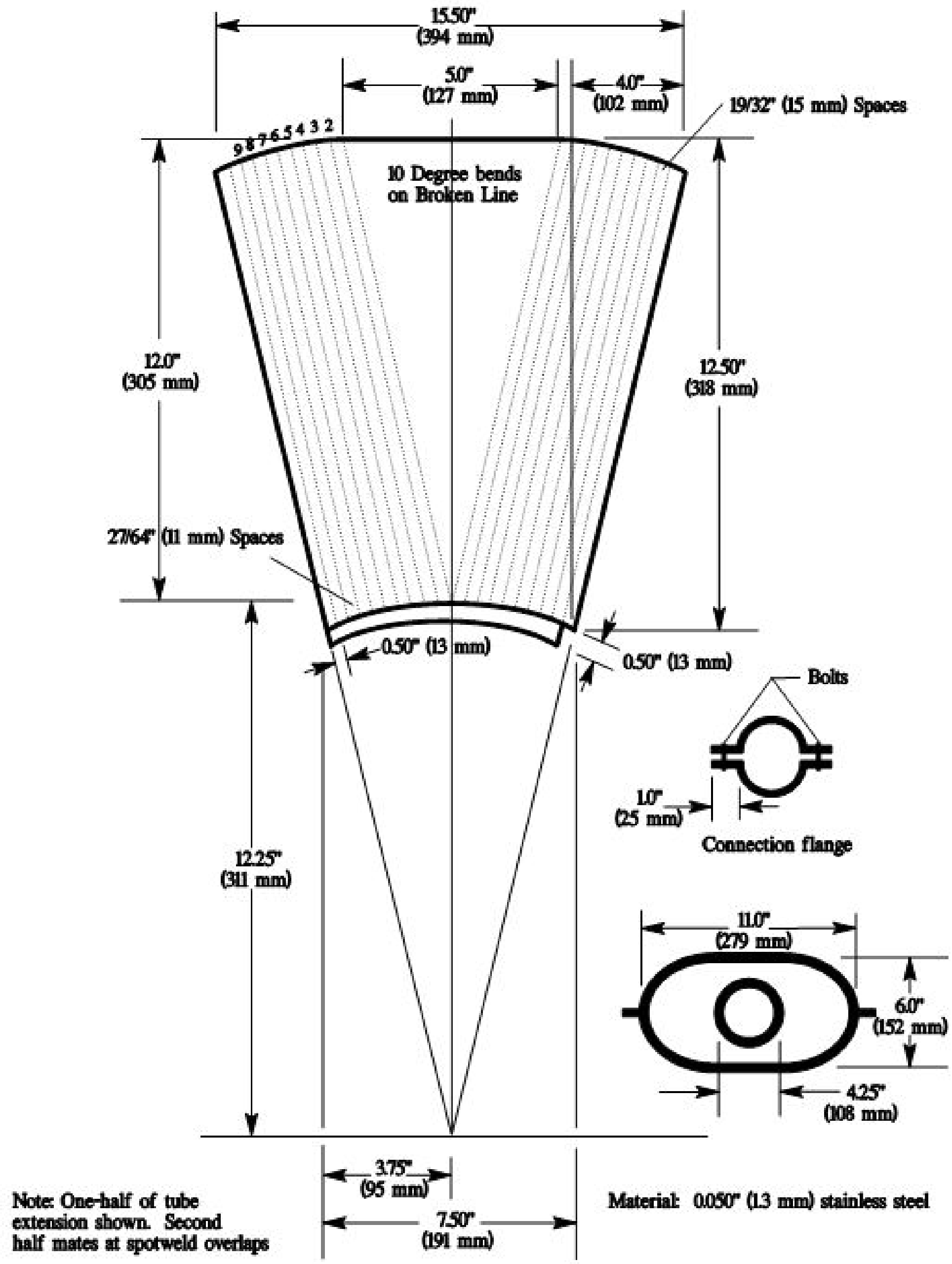


Figure D14-3. Burner draft tube extension cone diagram

D14.3.2.7 Fuel pressure regulator

Provide a fuel pressure regulator adjusted to deliver a nominal 6.0 gal/hr (0.378 L/min) flow rate. An operating fuel pressure of 100 lb/in^2 (0.71 MPa) for a nominally rated 6.0 gal/hr 80-degree spray angle nozzle (such as a PL type) delivers 6.0 ± 0.2 gal/hr (0.378 ± 0.0126 L/min).

D14.3.3 Calibration Rig and Equipment

D14.3.3.1 Heat-Flux and Temperature Measuring Rigs

Construct individual calibration rigs to incorporate a calorimeter and thermocouple rake for the measurement of heat flux and temperature. Position the calibration rigs to allow movement of the burner from the test rig position to either the heat flux or temperature position with minimal difficulty.

D14.3.3.2 Calorimeter

The calorimeter must be a total heat flux, foil-type Gardon gauge of an appropriate range, such as 0-20 Btu/ft^2-sec (0-22.7 W/cm^2), accurate to ±3% of the indicated reading. The heat-flux calibration method must be in accordance with paragraph (b)(7) of D13.3.7.2.

D14.3.3.2.1 Calorimeter Mounting

Mount the calorimeter in a 6- by 12- ± 0.125-inch (152- by 305- ± 3 mm) by 0.75 ± 0.125-inch-thick (19 mm ± 3 mm) insulating block, which is attached to the heat-flux calibration rig during calibration (see figure D14-4). Monitor the insulating block for deterioration, and replace it when necessary. Adjust the mounting as necessary to ensure that the calorimeter face is parallel to the exit plane of the test burner cone.

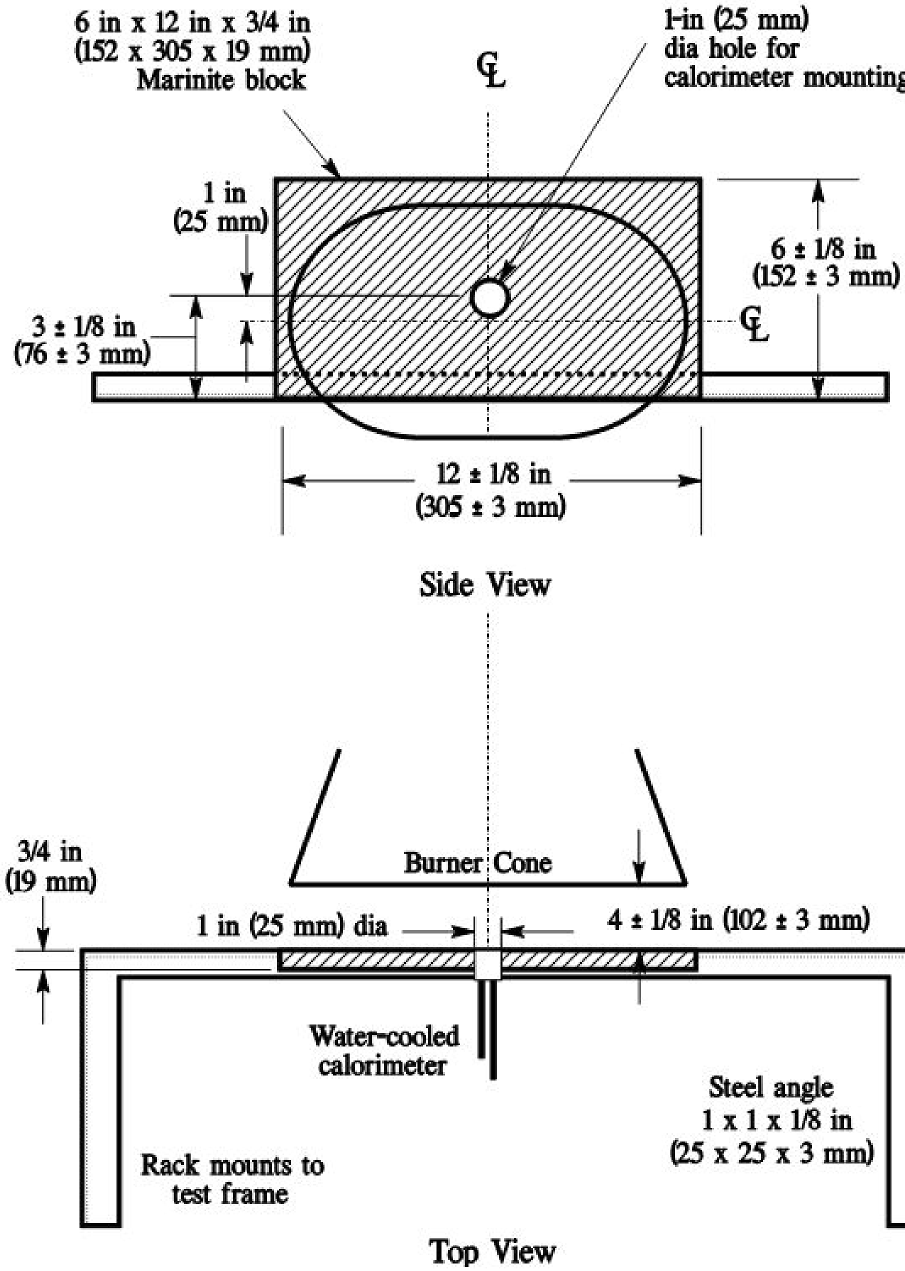


Figure D14-4. Calorimeter position respective of burner cone

D14.3.3.3 Thermocouples

Provide seven 0.125-inch (3.2 mm) ceramic-packed, metal-sheathed, type-K (chromel-alumel), grounded-junction thermocouples with a nominal 24 American Wire Gauge (AWG) size conductor for calibration. Attach the thermocouples to a steel angle bracket to form a thermocouple rake for placement in the calibration rig during burner calibration (see figure D14-5).

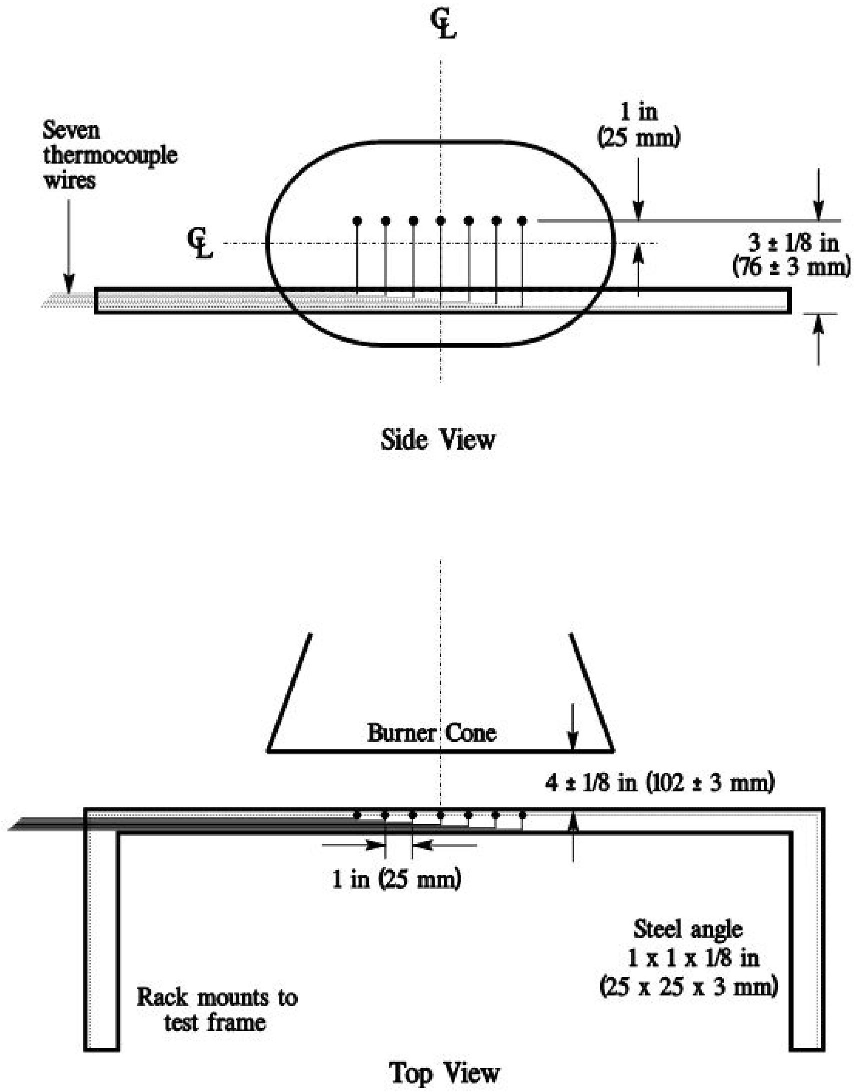


Figure D14-5. Thermocouple rake position respective of burner cone

D14.3.3.4 Air-Velocity Meter

Use a vane-type air-velocity meter to calibrate the velocity of air entering the burner. An Omega Engineering Model HH30A is satisfactory. Use a suitable adapter to attach the measuring device to the inlet side of the burner to prevent air from entering the burner other than through the measuring device, which would produce erroneously low readings. Use a flexible duct, measuring 4 inches wide (102 mm) by 20 feet (6.1 meters) long, to supply fresh air to the burner intake to prevent damage to the air velocity meter from ingested soot. An optional airbox permanently mounted to the burner intake area can effectively house the air-velocity meter and provide a mounting port for the flexible intake duct.

D14.3.4 Test Specimen Mounting Frame

Make the mounting frame for the test specimens of 0.125-inch-thick (3.2 mm) steel, as shown in figure D14-1, except for the center vertical former, which should be 1/4-inch (6.4 mm) thick to minimize warpage. The specimen mounting frame stringers (horizontal) should be bolted to the test frame formers (vertical) such that the expansion of the stringers will not cause the entire structure to warp. Use the mounting frame for mounting the two insulation blanket test specimens, as shown in figure D14-2.

D14.3.5 Backface Calorimeters

Mount two total heat-flux Gardon-type calorimeters behind the insulation test specimens on the back side (cold) area of the test specimen mounting frame, as shown in figure D14-6. Position the calorimeters along the same plane as the burner cone centerline at a distance of 4 inches (102 mm) from the vertical centerline of the test frame.

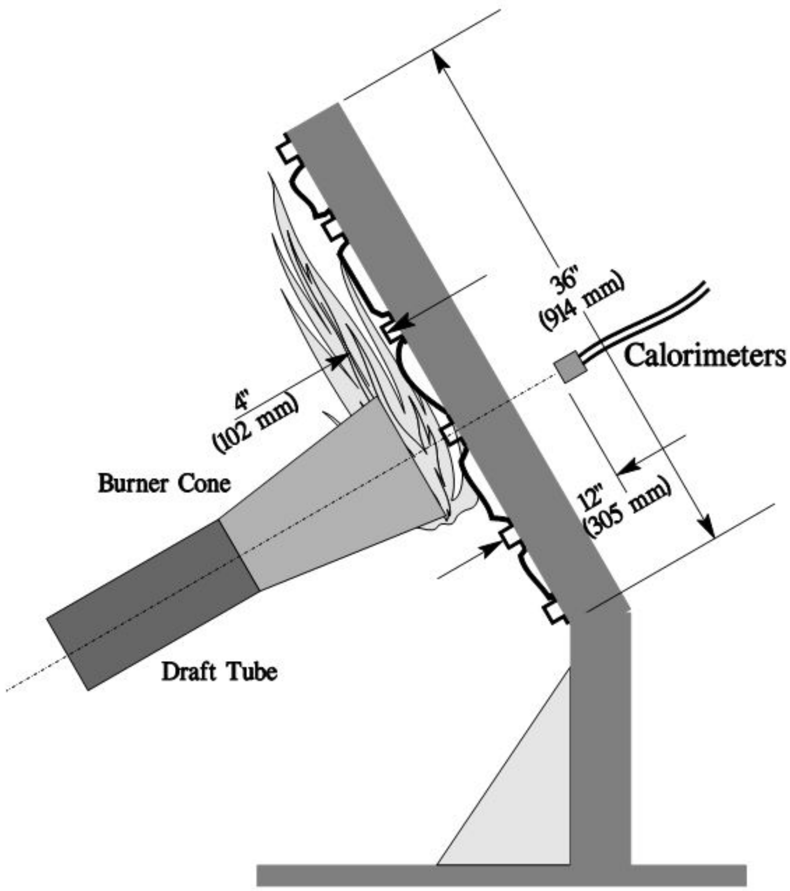


Figure D14-6. Position of backface calorimeters relative to test specimen frame

D14.3.5.1 Backface Calorimeter Requirements

The calorimeters must be a total heat-flux, foil-type Gardon gauge of an appropriate range, such as 0-5 Btu/ft^2-sec (0-5.7 W/cm^2), accurate to ±3% of the indicated reading. The heat-flux calibration method must comply with paragraph (b)(7) of section D13.3.7.2.

D14.3.6 Instrumentation

Provide a recording potentiometer or other suitable calibrated instrument with an appropriate range to measure and record the outputs of the calorimeter and the thermocouples.

D14.3.7 Timing Device

Provide a stopwatch or other device, accurate to ±1%, to measure the time of application of the burner flame and burnthrough time.

D14.3.8 Test Chamber

Perform tests in a suitable chamber to reduce or eliminate the possibility of test fluctuation due to air movement. The chamber must have a minimum floor area of 10 by 10 feet (305 by 305 cm).

D14.3.9 Ventilation Hood

Provide the test chamber with an exhaust system capable of removing the products of combustion expelled during tests.

D14.4 Test Specimens

D14.4.1 Specimen Preparation

Prepare a minimum of three specimen sets of the same construction and configuration for testing.

D14.4.2 Insulation Blanket Test Specimen

D14.4.2.1 For batt-type materials, such as fiberglass, the constructed, finished blanket specimen assemblies must be 32 inches wide by 36 inches long (81.3 by 91.4 cm), exclusive of heat-sealed film edges.

D14.4.2.2 For rigid and other nonconforming types of insulation materials, the finished test specimens must fit into the test rig in such a manner as to replicate the actual in-service installation.

D14.4.3 Construction

Make each of the specimens tested using the principal components (i.e., insulation, fire barrier material if used, and moisture barrier film) and assembly processes (representative seams and closures).

D14.4.3.1 Fire Barrier Material

If the insulation blanket is constructed with a fire barrier material, place the fire barrier material in a manner reflective of the installed arrangement. For example, if the material will be placed on the outboard side of the insulation material, inside the moisture film, place it the same way in the test specimen.

D14.4.3.2 Insulation Material

Blankets that utilize more than one variety of insulation (composition, density) must have specimen sets constructed that reflect the insulation combination used. If, however, several blanket types use similar insulation combinations, it is not necessary to test each combination if it is possible to bracket the various combinations.

D14.4.3.3 Moisture Barrier Film

If a production blanket construction utilizes more than one type of moisture barrier film, perform separate tests on each combination. For example, if a polyimide film is used in conjunction with an insulation to enhance the burnthrough capabilities, also test the same insulation when used with a polyvinyl fluoride film.

D14.4.4 Installation on Test Frame

Attach the blanket test specimens to the test frame using 12 steel spring-type clamps as shown in figure D14-7. Use the clamps to hold the blankets in place in both of the outer vertical formers, and the center vertical former (four clamps per former). The clamp surfaces should measure 1 inch by 2 inches (25 by 51 mm). Place the top and bottom clamps 6 inches (15.2 cm) from the top and bottom of the test frame, respectively. Place the middle clamps 8 inches (20.3 cm) from the top and bottom clamps.

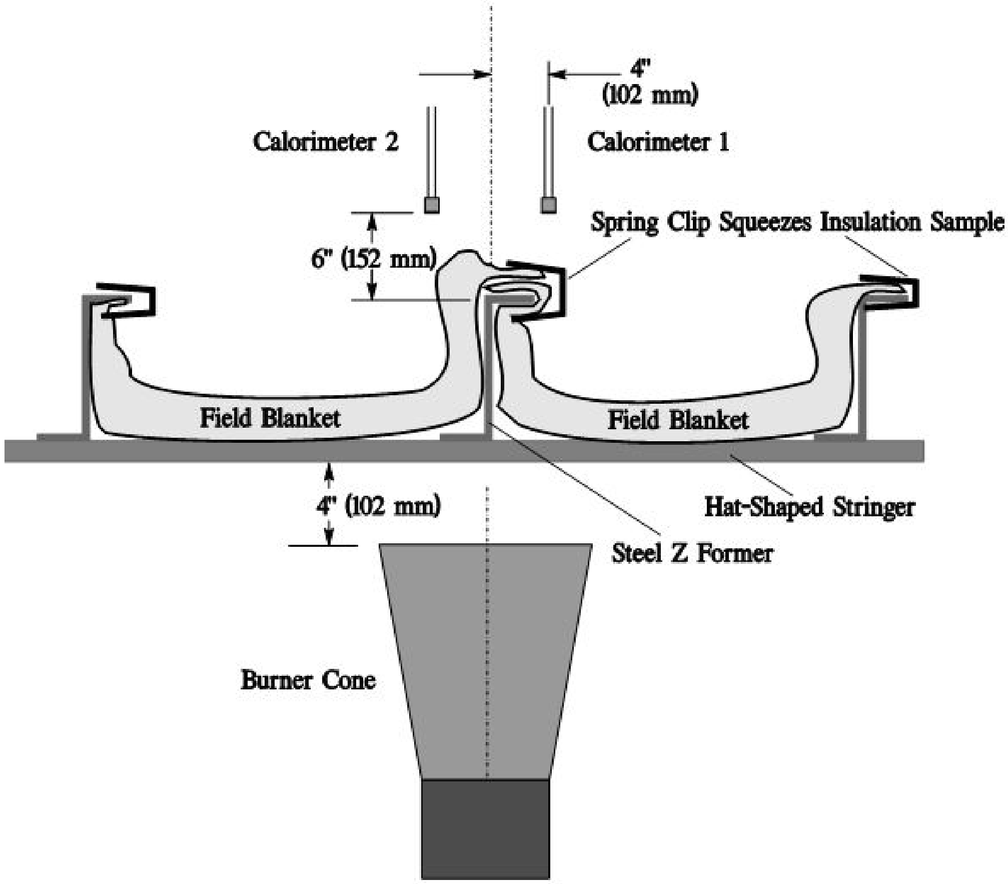


Figure D14-7. Test specimen installation on test frame

(Note: For blanket materials that cannot be installed in accordance with figure D14-7, the blankets must be installed in a manner approved by the FAA.)

D14.4.5 Conditioning

Condition the specimens at 70° ± 5°F (21° ± 2°C) and 55% ± 10% relative humidity for a minimum of 24 hours prior to testing.

D14.5 Preparation of Apparatus

D14.5.1 Apparatus Leveling

Level and center the frame assembly to ensure alignment of the calorimeter/ thermocouple rake with the burner cone.

D14.5.2 Air Velocity Measurement

Turn on the ventilation hood for the test chamber. Do not turn on the burner blower. Measure the airflow of the test chamber using a vane anemometer or equivalent measuring device. The vertical air velocity just behind the top of the upper insulation blanket test specimen must be 100 ± 50 ft/min (0.51 ± 0.25 m/s). The horizontal air velocity at this point must be less than 50 ft/min (0.25 m/s).

D14.5.3 Fuel Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow rate using a graduated cylinder of appropriate size. Turn on the burner motor/fuel pump after ensuring that the igniter system is turned off. Collect the fuel via a plastic or rubber tube into the graduated cylinder for a 2-minute period. Determine the flow rate in gallons per hour. The fuel flow rate must be 6.0 ± 0.2 gal/hr (0.378 ± 0.0126 L/min).

D14.6 Calibration

D14.6.1 Alignment of Instrumentation

Position the burner in front of the calorimeter so that it is centered and the vertical plane of the burner cone exit is 4 ± 0.125 inches (102 ± 3 mm) from the calorimeter face. Ensure that the horizontal centerline of the burner cone is offset 1 inch below the horizontal centerline of the calorimeter (see figure D14-8). Without disturbing the calorimeter position, rotate the burner in front of the thermocouple rake, such that the middle thermocouple (number 4 of 7) is centered on the burner cone.

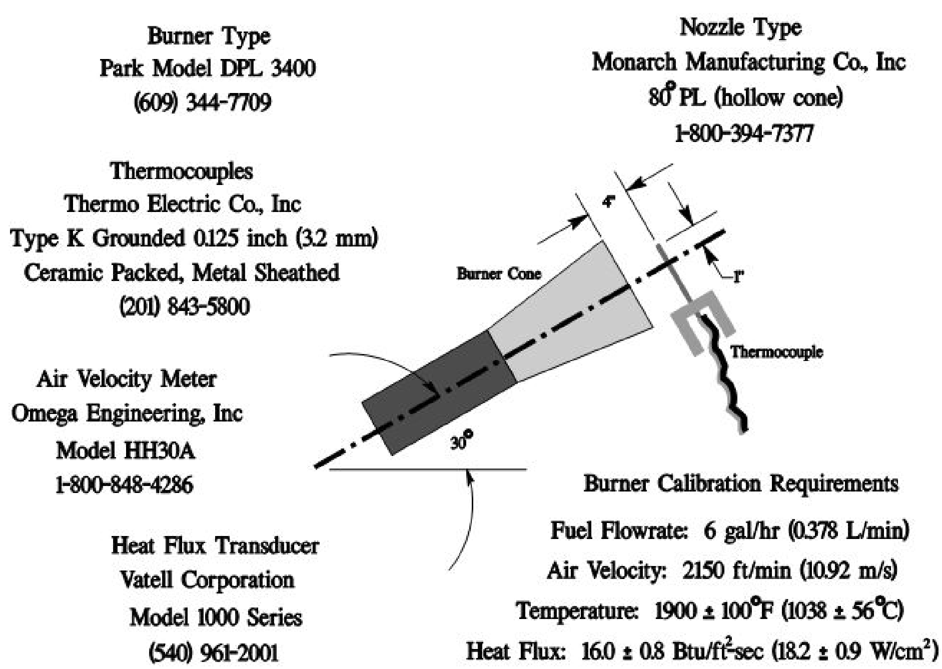


Figure D14-8. Burner information and calibration settings

Ensure that the horizontal centerline of the burner cone is also offset 1 inch below the horizontal centerline of the thermocouple tips. Recheck measurements by rotating the burner to each position to ensure proper alignment between the cone and the calorimeter and thermocouple rake.

NOTE: The test burner mounting system must incorporate "detents" that ensure proper centering of the burner cone with respect to both the calorimeter and the thermocouple rakes, so that rapid positioning of the burner can be achieved during the calibration procedure.

D14.6.2 Intake Air Adjustment

Position the air-velocity meter in the adapter or airbox, making certain that no gaps exist where air could leak around the air-velocity measuring device. Turn on the blower/motor while ensuring that the fuel solenoid and igniters are off. Adjust the air intake velocity to a level of 2150 ft/min (10.92 m/s), then turn off the blower/motor.

NOTE: The Omega HH30 air-velocity meter measures 2.625 inches in diameter. To calculate the intake airflow, multiply the cross-sectional area (0.03758 ft^2) by the air velocity (2150 ft/min) to obtain 80.80 ft^3/min. An air velocity meter other than the HH30 unit can be used, provided the calculated airflow of 80.80 ft^3/min (2.29 m^3/min) is equivalent.

D14.6.3 Instrumentation Cleaning and Final Check

Rotate the burner from the test position to the warmup position. Prior to lighting the burner, ensure that the calorimeter face is clean of soot deposits and there is water running through the calorimeter. Examine and clean the burner cone of any evidence of buildup of products of combustion or soot. Soot buildup inside the burner cone may affect the flame characteristics and cause calibration difficulties. Because the burner cone may distort with time, dimensions should be checked periodically.

D14.6.4 Heat-Flux Calibration

While the burner is still rotated to the warmup position, turn on the blower/motor, igniters, and fuel flow, and light the burner. Allow it to warm up for 2 minutes. Move the burner into the calibration position, and allow 1 minute for calorimeter stabilization, then record the heat-flux once every second for 30 seconds. Turn off the burner, rotate out of position, and allow to cool. Calculate the average heat flux over this 30-second duration. The average heat flux should be 16.0 ± 0.8 Btu/ft^2 sec (18.2 ± 0.9 W/cm^2).

D14.6.5 Temperature Calibration

Position the burner in front of the thermocouple rake. After checking for proper alignment, rotate the burner to the warmup position, turn on the blower/motor, igniters, and fuel flow, and light the burner. Allow it to warm up for 2 minutes. Move the burner into the calibration position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for 30 seconds. Turn off the burner, rotate out of position, and allow to cool. Calculate the average temperature of each thermocouple over this 30-second period and record. The average temperature of each of the seven thermocouples should be 1900°F ± 100°F (1038° ± 56°C).

D14.6.6 Burner Readjustment

If either the heat flux or the temperatures are not within the specified range, adjust the burner intake air velocity and repeat the procedures in paragraphs D14.6.4 and D14.6.5 to obtain the proper values. Ensure that the inlet air velocity is within the range of 2150 ft/min ± 50 ft/min (10.92 ± 0.25 m/s).

D14.6.7 Calibration Frequency

Calibrate prior to each test until consistency has been demonstrated. After consistency has been confirmed, several tests may be conducted with calibration conducted before and after a series of tests.

D14.7 Test Procedure

D14.7.1 Secure the two insulation blanket test specimens to the test frame. The insulation blankets should be attached to the test rig center vertical former using four spring clamps positioned as shown in figure D14-7 (according to the criteria of paragraph D14.4.4 of this chapter).

D14.7.2 Ensure that the vertical plane of the burner cone is at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the outer surface of the horizontal stringers of the test specimen frame, and that the burner and test frame are both situated at a 30 degree angle with respect to vertical.

D14.7.3 When ready to begin the test, direct the burner away from the test position to the warmup position so that the flame will not impinge on the specimens prematurely. Turn on and light the burner, and allow it to stabilize for 2 minutes.

D14.7.4 To begin the test, rotate the burner into the test position and simultaneously start the timing device.

D14.7.5 Expose the test specimens to the burner flame for 4 minutes, and then turn off the burner. Immediately rotate the burner out of the test position.

D14.7.6 Determine (if applicable) the burnthrough time or the point at which the heat flux exceeds 2.0 Btu/ft^2-sec (2.27 W/cm^2).

D14.8 Report

D14.8.1 Identify and describe the specimen being tested.

D14.8.2 Report the number of insulation blanket specimens tested.

D14.8.3 Report the burnthrough time (if any), the maximum heat flux on the back face of the insulation blanket test specimen, and the time at which the maximum occurred.

D14.9 Requirements

D14.9.1 The two insulation blanket test specimens must not allow fire or flame penetration in less than 4 minutes.

D14.9.2 The two insulation blanket test specimens must not allow more than 2.0 Btu/ft^2-sec (2.27 W/cm^2) on the cold side of the insulation specimens at a point 12 inches (30.5 cm) from the face of the test rig.

CHAPTER E: POWERPLANT FLAMMABILITY TESTS

Chapter E1
Powerplant Hose Assemblies Test

E1.1 Scope

E1.1.1 This test method can be used to determine the fire resistance of high-temperature hose assemblies used in designated fire zones to flame and vibration damage for showing compliance with TSO C42, C53A, and C75.

E1.1.2 The requirements and procedures of this test method vary according to hose materials and hose assembly application.

E1.2 Definitions

E1.2.1 Designated Fire Zone

A designated fire zone is defined as a region of the aircraft, such as engine and auxiliary power unit compartments, designated to require fire detection and extinguishing equipment and, as appropriate, the use of materials that are fire resistant or fireproof.

E1.2.2 Fireproof

Per 14 CFR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “in designated fire zones means “the capacity to withstand at leathe capacity to withstand at least as well as steel in dimensions appropriate for the purpose for which they are used, the heat produced when there is a severe fire of extended duration in that zone as well as steel in dimensions appropriate for the purpose for which they are used, the heat produced when there is a severe fire of extended duration in that zone”

Powerplant hose assemblies are demonstrated to be fireproof by meeting the requirements of this test for a flame exposure time of 15 minutes.

E1.2.3 Fire Resistant

Per 14 CFR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “with respect to fluid-carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls, means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.”

Powerplant hose assemblies are demonstrated to be fire resistant by meeting the requirements of this test for a flame exposure time of 5 minutes.

E1.2.4 Class A Hose Assembly

A Class A hose assembly is defined as a hose assembly capable of withstanding exposure to this fire test procedure for 5 minutes without failure (e.g., leaking circulating oil) per TSO C53a.

E1.2.5 Class B Hose Assembly

A Class B hose assembly is defined as a hose assembly capable of withstanding exposure to this fire test procedure for 15 minutes without failure (e.g., leaking circulating oil) per TSO C53a.

E1.2.6 Velometer

A device for measuring airflow velocity.

NOTE: A velometer manufactured by Alnor Instrument Company, 7555 North Linder Avenue, Skokie, Illinois 60077-3822, catalog number 01518, has been found satisfactory.

E1.2.7 Photocell

An electronic device having output that varies in response to the intensity of incident visible light.

E1.3 Apparatus

E1.3.1 Test Burner

A modified gun-type conversion oil burner, as described in table E1-1, will be used. The burner will be calibrated to provide a minimum average flame temperature of 2000°F (1100°C) and a minimum heat input of 4500 Btu/hr to the Btu heat transfer device described in section E1.3.3.2, or 9.3 Btu/ft^2-sec (10.6 W/cm^2), as measured by a calorimeter described in section E1.3.3.1.

Table E1-1. Test burner information

Burner Standard Model Designation	Power Supply	Test Nozzle	Test Fuel Flow -0, +0.05 gal/hr	Test Air Pressure in Draft Tube (ref)	Modifications to Standard Burner
Stewart Warner HPR-250 This burner is no longer available. Supplier Stewart-Warner Corp. Heating & Air Conditioning Lebanon, Indiana 46052	1/4 HP/115V/ 60Hz/single ph	2.25 gal/hr 80-degree angle	2 gal/hr (95-psig pump press ref)	0.14 in H_2O	1. Air tube diameter reduced to 2.5 inches (63.5 mm), starting 1.5 inches (38 mm) forward of nozzle tip. 2. Added four 0.75- by 0.0625-inch (19- by 1.59-mm) stainless-steel fuel deflectors mounted on the reducing cone at 3, 6, 9, and 12 o'clock. The deflector edges were 3.4 inches (19 mm) off center line (CL) and 3.4 inches (19 mm) forward of fuel nozzle up. 3. Added static air pressure port 1 inch (25.4 mm) forward of the burner tube mounting flange. 4. Added a 12.5-inchinch (317.5 mm) burner extension so that the wide end is 10 inches (254 mm) beyond the end of the air tube.
Stewart Warner FR-600 This burner is no longer available. Supplier Stewart-Warner Corp. Heating & Air Conditioning Lebanon, Indiana 46052	1/3 HP/115V/ 60Hz/single ph	Same as above	2 gal/hr (100-psig pump press ref)	0.01 in H_2O	1. Air tube diameter reduced to 2.5 inches (63.5 mm), starting 1.5 inches (38 mm) forward of nozzle tip. 2. Added four 0.75- by 0.0625-inch (19- by 1.59-mm) stainless-steel fuel deflectors mounted on the reducing cone at 3, 6, 9, and 12 o'clock. The deflector edges were 3.4 inches (19 mm) off CL and 3.4 inches (19 mm) forward of fuel nozzle up. 3. Added static air pressure port 1 inch (25.4 mm) forward of the burner tube mounting flange. 4. Added a 12.5-inch (317.5-mm) burner extension so that the wide end is 10 inches (254 mm) beyond the end of the air tube.
Lennox OB-32 (This is now obsolete and cannot be purchased.)		2.25 gal/hr 80-degree angle	2 gal/hr (80-psig pump press ref)	0.17 in H_2O	1. Added a 12.5-inch (317.5 mm) burner extension.

Table E1-1. Test burner information (continued)

Burner Standard Model Designation	Power Supply	Test Nozzle	Test Fuel Flow -0, +0.05 gal/hr	Test Air Pressure in Draft Tube (ref)	Modifications to Standard Burner
Carlin 200CRD This burner is not available with modifications. Supplier Carlin Co. 912 Silas Dean Hwy Wethersfield, Conn. 06109	1/4 HP/115V/ 60Hz/single ph	Same as above	2 gal/hr (97-lb/in^2 pump press ref)	0.37 in H_2O	1. Disassemble the burner air tube assembly and remove the throttle ring and the retention ring. 2. Remove the existing fuel nozzle and install an 80-degree, 2.25-gal/hr nozzle. After reassembly, adjust the outside diameter delivery rate to 2.01 gal/hr at 97 lb/in^2 gauge. 3. Using 0.0625-inch stainless-steel material, manufacture and install three deflectors. 4. Manufacture a flat-disk plate to match the inside diameter of the burner air tube and randomly punch 10.5-inch holes as shown. The main purpose of this disk is to center the oil delivery tube. Locate and punch holes for the ignitors and the oil delivery tube. A pie-shaped segment was cut out for ease of installation and the split-baffle mounting bracket was secured to the oil delivery tube with a small hose clamp. Position this flat-disk plate 4 inches aft of the fuel nozzle. 5. Manufacture and install a reducing cone. The outside diameter of this cone should match the inside diameter of the oil burner air tube. This cone is secured in place with small Allen or socket head screws. 6. Install the static pressure port 1 inch forward of the air tube mounting flange and adjust the air pressure in the air tube to approximately 0.37 inch of H_2O during operation. 7. Manufacture a 12.5-inch burner air tube extension and install this extension so that the wide end is 10 inches beyond the end of the burner air tube.

Table E1-1. Test burner information (continued)

Burner Standard Model Designation	Power Supply	Test Nozzle	Test Fuel Flow -0, +0.05 gal/hr	Test Air Pressure in Draft Tube (ref)	Modifications to Standard Burner
Park DPL 3400 Supplier Park Manufacturing Company New York and Absecon Blvd. Atlantic City, New Jersey 08401					This burner will be built to the FAA's specifications on request.

E1.3.1.1 Burner Extension

A stainless-steel funnel extension, fabricated in accordance with figure E1-1, will be used. The funnel will have an oblong exit 6 inches (152 mm) high by 11 inches (279 mm) wide. The funnel will be installed on the burner with the air tube shown in figure E1-2.

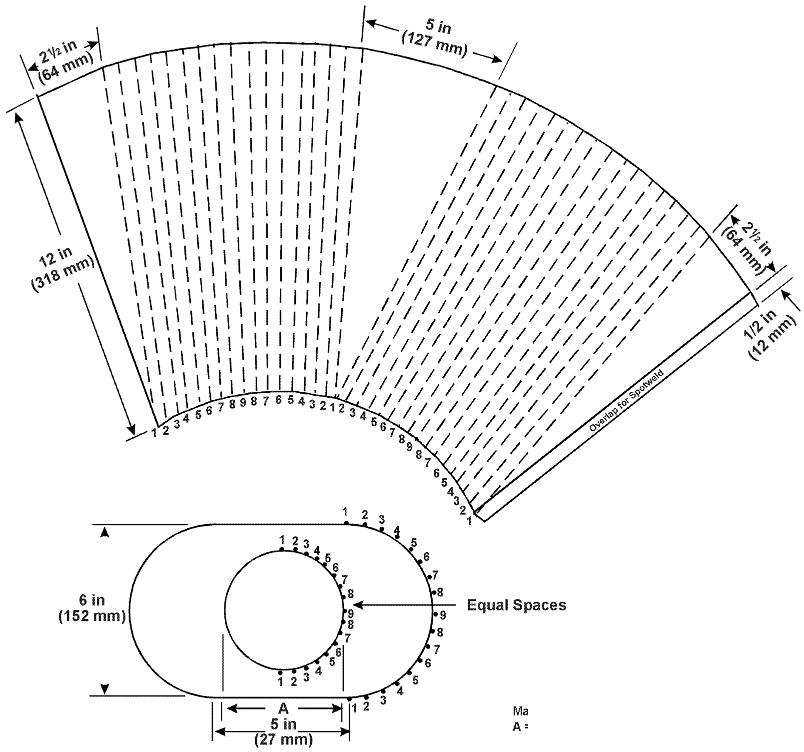


Figure E1-1. Burner extension funnel

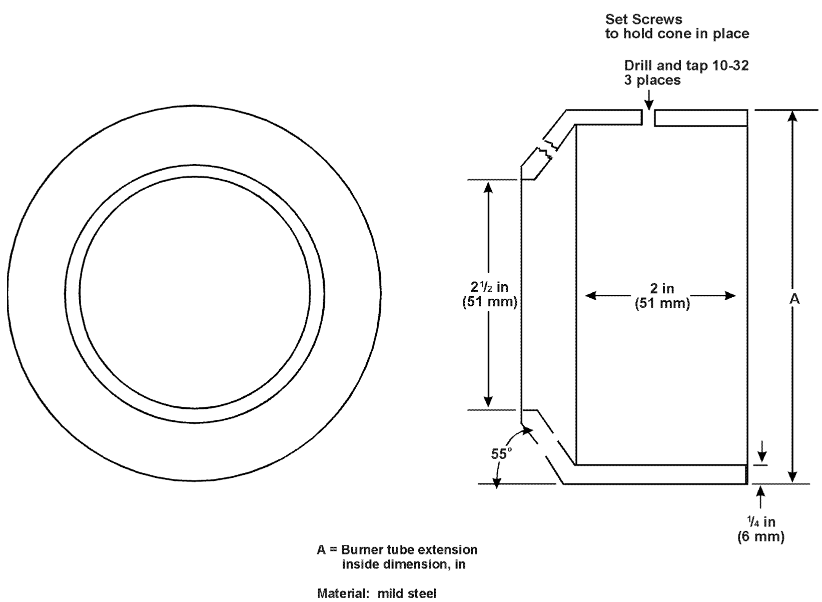


Figure E1-2. Air tube reducing cone

E1.3.1.2 Burner Fuel

Society of Automotive Engineers (SAE) No. 2 diesel, kerosene, or equivalent will be used for burner fuel.

E1.3.2 Thermocouples

A thermocouple rake containing at least five American National Standard Institute (ANSI) 22-gauge chromel-alumel (Type K) thermocouples sheathed in 0.0625-inch-thick (1.6-mm) stainless-steel or inconel tubes, or equivalent, will be provided. The thermocouples will be aligned in a row 1 ± 0.1 inches (25 ± 3 mm) apart.

E1.3.3 Heat-Flux Measuring Device

One of the following devices will be used to measure the heat-flux density of the flame.

E1.3.3.1 Calorimeter

A water-cooled calorimeter capable of measuring heat-flux densities up to 15 Btu/ft^2-sec (17 W/cm^2) may be provided for burner calibration. A Hy-Cal model 1300A total heat-flux density calorimeter available from Hy-Cal Engineering, Santa Fe Springs, California, or equivalent has been found suitable.

E1.3.3.2 Btu Heat Transfer Device

Figures E1-4 to E1-10 show fabrication details of an acceptable copper tube device used to measure heat-flux density. The mercury thermometers will be positioned in the mounting tubes so that the bottom of the bulb is within 1/16 inch (1.6 mm) of the bottom of the passage in the heat transfer tube (see figures E1-7 and E1-8).

NOTE: A satisfactory version of the woven copper fabric shown in figure E1-5 is manufactured by Metal Textile Corporation, Roselle, New Jersey.

E1.3.3.2.1 Thermometers

Two glass scientific thermometers calibrated in 0.1°F (0.05°C) increments, immersible thermocouples, or equivalent will be provided for the heat transfer tube assembly.

E1.3.4 Test Setup

A steel table measuring 60 inches (1524 mm) wide, 28 inches (711 mm) deep, and 32 inches (813 mm) high has been found acceptable. The vibrating mechanism and hood, described below, may be mounted on this table. See figure E1-1 for an acceptable test setup.

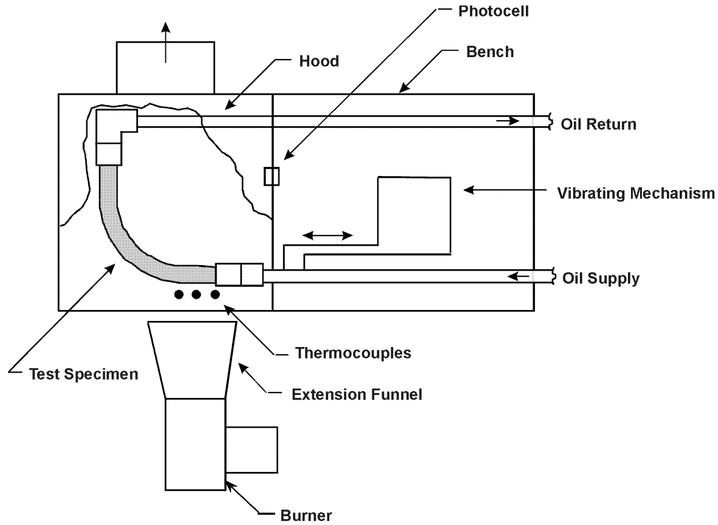


Figure E1-3. Hose assemblies test setup

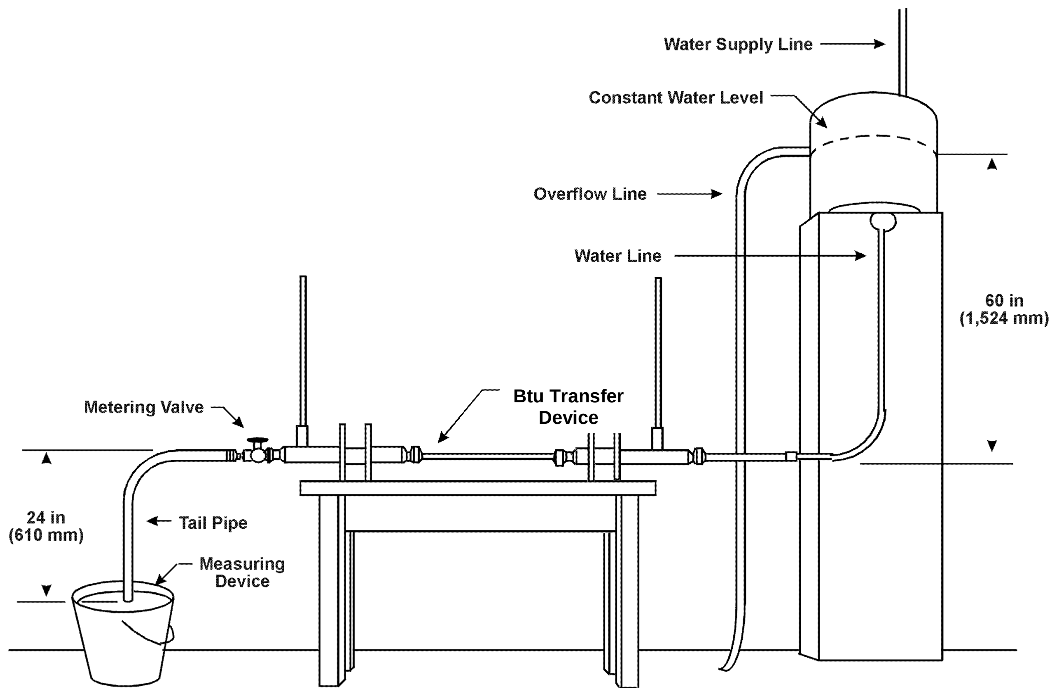


Figure E1-4. Burner calibration standardization apparatus

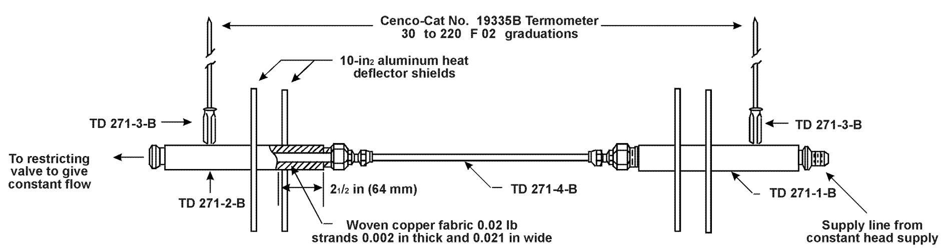


Figure E1-5. BTU heat transfer device

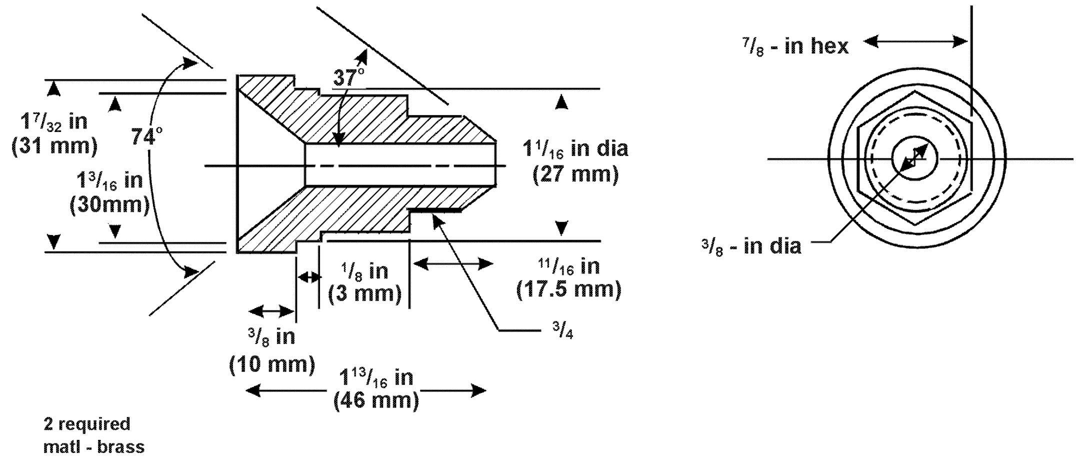


Figure E1-6. BTU heat transfer device—Reducer

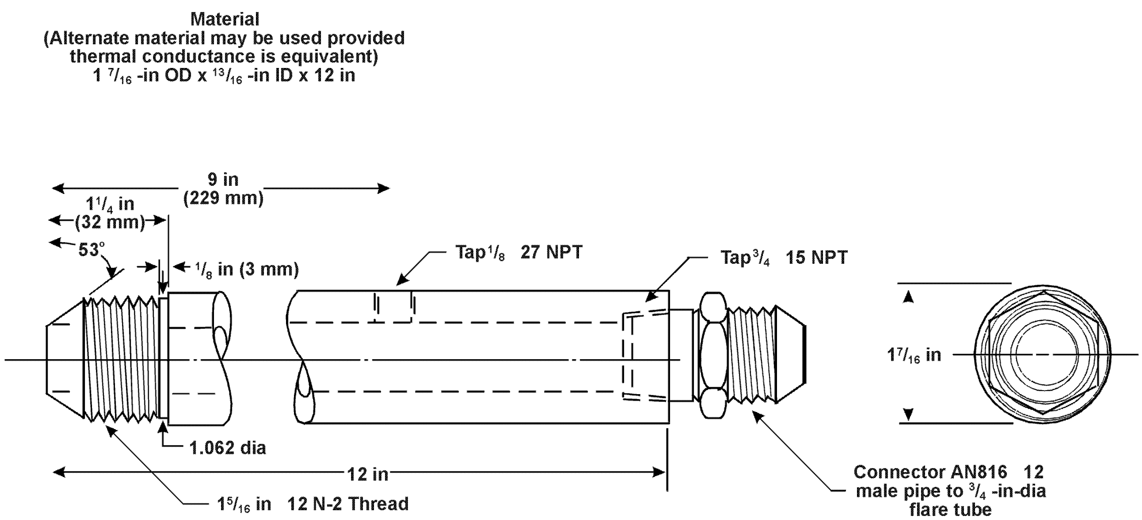


Figure E1-7. BTU heat transfer device—Inlet tube

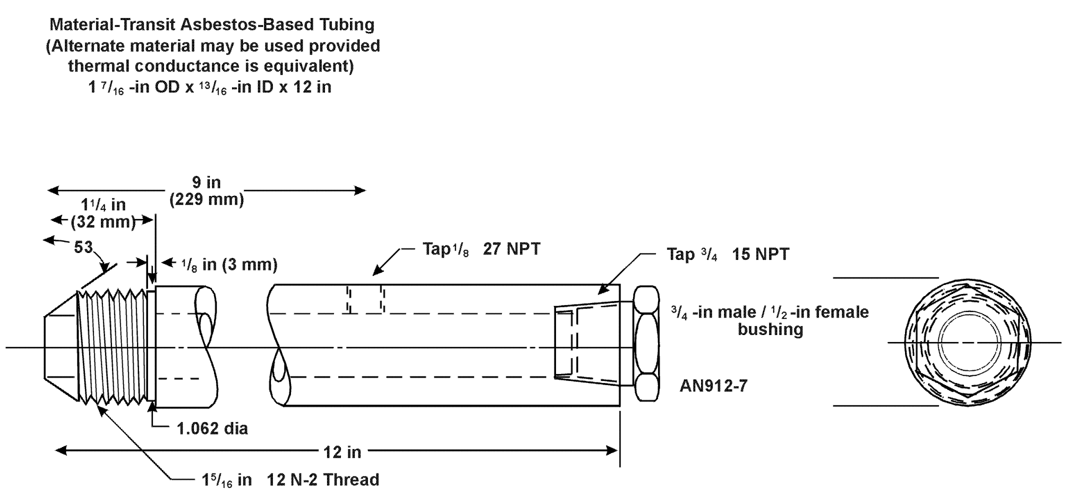


Figure E1-8. BTU heat transfer device—Outlet tube

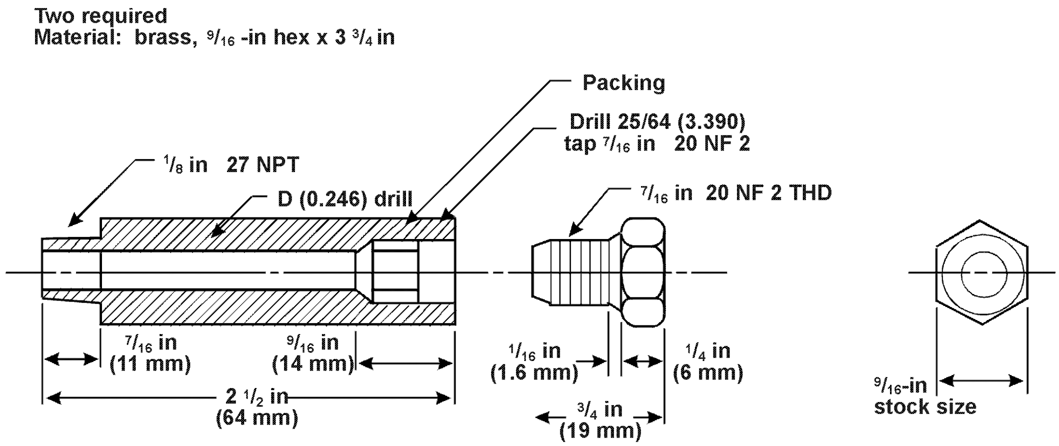


Figure E1-9. BTU heat transfer device—Thermometer mounting

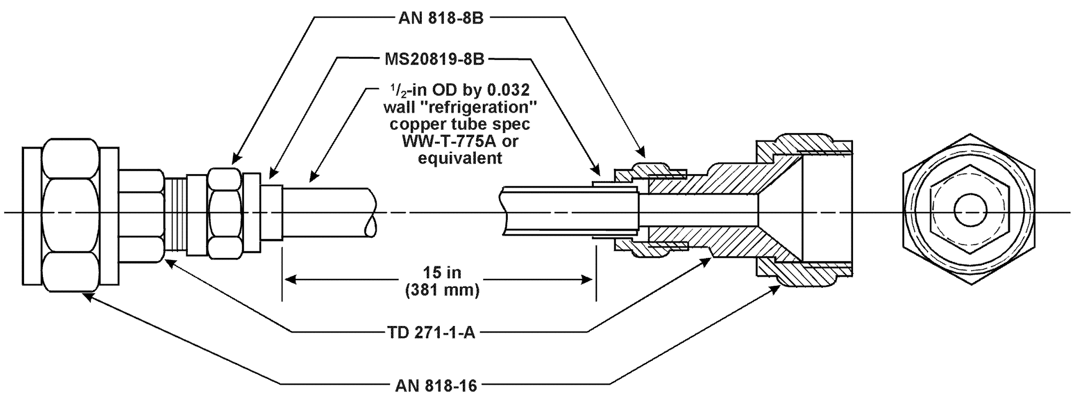


Figure E1-10. BTU heat transfer device—Test specimen

E1.3.4.1 Vibration Source

A means will be provided to vibrate the hose assembly, as shown in figure E1-8, at 33 Hz with a total displacement of a least 0.125 inch (3.2 mm), i.e., with an amplitude of at least 0.0625 inch (1.6 mm).

E1.3.4.2 Hood

A hood measuring 25 inches (635 mm) wide and 25 inches (635 mm) high has been found acceptable. The hood may be placed on the bench near the vibration source so that the vibrating fitting for the hose attachment is located 7 inches (178 mm) behind the open front of the hood.

E1.3.4.2.1 Fan

The hood will have a fan installed on the rear to draw air through it at a velocity of 400 ft/min (203 cm/s), as measured by a velometer located at the position occupied by the hose assembly specimen during the test.

E1.3.4.2.2 Photocell

The hood may contain a photocell to detect a flareup resulting from burning oil due to a hose failure.

E1.3.4.3 Automatic Shutdown System

If a flareup of burning oil escaping from a failed hose assembly is detected, an automatic shutdown system may be provided to terminate the test by turning off the burner, vibrating mechanism, hood fan, and oil flow.

E1.3.4.4 Temperature Measuring and Recording Equipment

A temperature sensing system will be provided that includes a sufficient number of thermocouples to ensure that the specified temperature exists along the entire end fitting and along the hose for a distance of not less than 5 inches (127 mm). The system will include a recorder to monitor the flame temperature throughout the fire-test duration.

NOTE: Permanent installation of temperature measuring thermocouples and a continuous recorder has been added for better control of the flame temperature during calibration and test.

E1.3.5 Oil Circulator and Heater

A device consisting of an oil tank with a temperature-controlled immersion heater and an electric oil pump will be provided if the hose assembly being tested must have oil pumped through the hose(s) during the test. The plumbing will include appropriate flow indicators, pressure gauges, control and selector valves, and pressure-relief valves.

E1.3.5.1 Oil

SAE No. 20 oil, in accordance with Military Specification MIL-L-2104C or equivalent, will be provided and used in the oil circulator and heater to pump through the hose assembly test specimen during the test.

E1.4 Test Specimens

E1.4.1 Prepare three specimens, 24 inches (610 mm) long, for the test.

E1.4.2 The configuration of the hose test specimens will be as used in service. A firesleeve may be added to the hose assembly, if needed, to enable the test specimens to withstand the fire test duration specified.

NOTE: If the addition of a firesleeve is required for a hose type to pass the test, a firesleeve must be fitted to that hose type before it can be used in designated fire zones on an airplane.

E1.5 Calibration

E1.5.1 Place the thermocouple rake on the test stand at a distance 4 inches (102 mm) above the centerline of the burner extension. Connect the thermocouples to a stripchart recorder.

E1.5.2 Light the burner, allow a 3-minute warmup, and move the burner into test position.

E1.5.3 Begin monitoring the temperatures indicated by the thermocouples after 3 minutes. Make adjustments as necessary to either the gas flow or the airflow to the burner to achieve a minimum average thermocouple reading of 2000°F (1100°C).

E1.5.4 Turn the burner off, move it out of test position, and remove the thermocouple rake.

E1.5.5 Replace the thermocouple rake with the heat-flux measuring device. Follow section E1.5.5.1 if using a water-cooled calorimeter for measuring heat flux. Follow section E1.5.5.2 if using a Btu heat transfer device for this purpose.

E1.5.5.1 If using the water-cooled calorimeter described in section E1.3.3.1, place the calorimeter at the same distance as the thermocouple rake centered over the burner exit.

E1.5.5.1.1 Light the burner, allow a 2-minute warmup, and move the burner into test position.

E1.5.5.1.2 Measure the heat-flux density continuously or at intervals no greater than 10 seconds. If the heat-flux density is not at least 9.3 Btu/ft^2-sec (10.6 W/cm^2), readjust the burner to achieve the proper heat flux. If burner adjustments are necessary, remove the heat-flux measuring device and repeat sections E1.5.1 through E1.5.5.1.2.

E1.5.5.2 If using the Btu heat transfer device described in section E1.3.3.2, ensure the external surface of the copper tubing on the Btu heat transfer device is clean prior to measuring heat flux. Use fine steel wool to clean the copper tubing. Inspect the tubing bore for corrosion and scale accumulation, and remove before each test. A .45-caliber pistol cleaning brush with an extension, or equivalent, has been found suitable for this purpose.

E1.5.5.2.1 The calibration setup is shown in figure E1-3. Provide a 5-foot (1.5 m) constant head of water above the heat transfer device and a 2-foot (0.61 m) drop to the end of the tailpipe for adjustment of the water flow rate. Use a 1-gallon (3.8 L) measuring container (a container and a weighing scale are also acceptable). Adjust the water flow rate to 500 lb/hr (227 kg/hr) or 1 gal/min (3.8 L/min). Supply water at a temperature of 50° to 70°F (10° to 21°C).

E1.5.5.2.2 Start the water flowing through the Btu heat-transfer device. Center the heat-transfer tube in the flame at the same location where a hose assembly would be placed for testing. Allow a 2-minute warmup period to stabilize flame conditions before temperature measurements from the mercury thermometers are recorded.

E1.5.5.2.3 After the warmup period, record the inlet and outlet temperatures every 30 seconds for a 3-minute period. Determine the rate of Btu increase of the water as follows:

Heat transfer = $146 \times (T_o - T_i)$ watts (for Celsius)

= $500 \times (T_o - T_i)$ Btu/hr (for Fahrenheit)

where:

To = temperature (°C or °F) at outlet

Ti = temperature (°C or °F) at inlet

E1.5.5.2.4 The heat rate output, as determined by the equation shown in section E1.5.5.2.3, will be a minimum of 4500 Btu/hr. If the heat output from the burner is not above this minimum, make adjustments to the burner and repeat sections E1.5.1 through E1.5.5.2 until the burner is within tolerance.

E1.6 Procedure

E1.6.1 Specimen Mounting

Mount the hose assembly in the test setup to include at least one full 90-degree bend so that the pressure existing inside the hose will exert an axial force on the hose end fitting. Locate the hose assembly 4 inches (102 mm) beyond the burner barrel extension so that the entire hose-assembly end fitting and at least 5 inches (127 mm) of the hose are exposed to the flame. Install the entire hose assembly inside the hood unless limited by the physical characteristics of the hose, such as minimum bend radius (see figure E1-1).

E1.6.2 Preheat the oil in the oil tank to 200° ± 10°F (93° ± 6°C). Start the oil-circulating pump, and circulate the oil through the test hose assembly at a flow rate and pressure as specified by hose type, size, and application. Pressures and flow rates are as shown in table E1-2.

NOTE: Flow rate values given in table E1-2 were derived from the most recent TSO C53. Flow rates used for the test will be minimum flow rates given for the actual installation, if known.

Table E1-2. Circulating oil pressure and flow rate

	Circulating Oil		
		Flow Rate	
Hose Type	Pressure	GPM	L/min
1a	System Working	$5 \times ID\ (in)^2$	$0.03 \times ID\ (mm)^2$
1b	System Working	$1 \times ID\ (in)^2$	$0.006 \times ID\ (mm)^2$
11a	System Working	$5 \times ID\ (in)^2$	$0.03 \times ID\ (mm)^2$
11b	System Working	$1 \times ID\ (in)^2$	$0.006 \times ID\ (mm)^2$

E1.6.3 Start the vibrating mechanism and observe the movement of the hose. Ensure that no whipping of the hose occurs.

E1.6.4 Start the hood air fan and begin monitoring the thermocouple recorder.

E1.6.5 Start the burner. Periodically observe the recorded temperature to ensure that the required minimum flame temperature of 2000°F (1093°C) is maintained.

E1.6.6 Terminate the test if a flareup of burning oil occurs because of a hose failure.

E1.6.7 Terminate the test after the required test duration has been reached (i.e., 5 minutes for Class A hose assemblies and 15 minutes for Class B hose assemblies).

E1.6.7.1 Stop the burner.

E1.6.7.2 Relieve the oil pressure in the hose assembly.

E1.6.7.3 Turn off the temperature recorder.

E1.7 Report

E1.7.1 Fully identify the hose configuration, including the assembly and fittings, and the class for which it is being tested.

E1.7.2 Report if there were any flareups of leaking oil and any other pertinent observations.

E1.7.3 Report whether the hose configuration met the requirements of Class A or Class B assemblies.

E1.8 Requirements

E1.8.1 Class A Hose Assembly

A Class A assembly will withstand the test procedure in section 6 for at least 5 minutes without leaking circulating oil.

E1.8.2 Class B Hose Assembly

A Class B hose assembly will withstand the test procedure described in section 6 for at least 5 minutes without leaking circulating oil.

Chapter E2
Powerplant Fire Penetration Test

E2.1 Scope

E2.1.1 This test method is intended to determine the capability of components and constructions to control the passage of fire or its effects in powerplant (engine) compartments and prevent additional hazard to the aircraft.

NOTE: Advisory Circular AC 20-135,Change 1, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria," October 11, 2018.

E2.1.2 This test is used to show compliance with 14 CFR 25.867, 25.865, 25.1191, and 25.1193.

E2.2 Definitions

E2.2.1 Firewall

A firewall is a structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a fire zone in which a fire has erupted and causing hazard to the aircraft. Firewalls must be fireproof.

E2.2.2 Fireproof

Per 14 CFR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) in designated fire zones means "the capacity to withstand at leathe capacity to withstand at least as well as steel in dimensions appropriate for the purpose for which they are used, the heat produced when there is a severe fire of extended duration in that zone as well as steel in dimensions appropriate for the purpose for which they are used, the heat produced when there is a severe fire of extended duration in that zone."

E2.2.2.1 Materials or parts are demonstrated to be fireproof by meeting requirements of this test for a flame exposure of 15 minutes.

E2.2.3 Fire Resistant

Per 14 CFR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) "with respect to fluid carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned."

E2.2.3.1 Materials or parts are demonstrated to be fire resistant by meeting the requirements of this test for a flame exposure of 5 minutes.

E2.2.4 Heat-Flux Density

The rate of thermal energy transferred per unit area, expressed here in units of Btu/ft^2-sec or W/cm^2.

E2.3 Apparatus

E2.3.1 Test Burner

The burner will be a modified gun-type oil burner, such as Part Model DPL 3400, Stewart Warner HPR-250 or FR 600, Lennox OB-32, or Carlin 200 CRD. The burner will be calibrated to provide a minimum average flame temperature of 2000°F (1093°C) and a minimum heat transfer rate of 4500 Btu/hr to the Btu heat transfer device described in chapter 11, section E1.3.3.2, or 9.3 Btu/ft^2-sec (10.6 W/cm^2) as measured by a calorimeter described in section E1.3.3.1.

NOTE: An SAE AS401B Propane Burner is also acceptable if the temperature profile and heat-flux density conform to the requirements specified in this test method.

E2.3.1.1 Burner Extension

A stainless-steel funnel extension fabricated in accordance with figure E1-1 will be used. The funnel will have an oblong exit 6 inches (152 mm) high by 11 inches (279 mm) wide. The funnel will be installed on the burner with the air tube shown in figure E1-2.

E2.3.1.2 Burner Fuel

SAE No. 2 diesel, kerosene, or equivalent will be used for burner fuel.

E2.3.2 Thermocouples

A thermocouple rake containing at least five ANSI 22-gauge chromel-alumel (Type K) thermocouples sheathed in 0.0625-inch (1.6 mm) stainless-steel or inconel tubes or equivalent will be provided. The thermocouples will be aligned in a row, 1.0 ± 0.1 inch (25 ± 2 mm) apart.

NOTE: Thermocouples can be either grounded or ungrounded, depending on the type of data system used to monitor thermocouple output. One condition may generate more interference with instrumentation than the other.

E2.3.3 Heating Rate Measuring Devices

One of the following devices will be used to measure the heating rate of the flame.

E2.3.3.1 Btu Heat Transfer Device

A Btu heat transfer device described in Chapter E1, "Power Plant Hose Assemblies Test," figures E1-5 to E1-10, in this handbook may be used.

E2.3.3.2 Calorimeter

A calorimeter capable of measuring heat-flux densities up to 15 Btu/ft-sec (17 W/cm) may be used. A Hy-Cal model 1300A total heat-flux density calorimeter available from Hy-Cal Engineering, Santa Fe Springs, California, or equivalent with water cooling has been found suitable.

E2.3.4 Test Stand

A test stand will be provided to maintain the position of the thermocouple rake, calorimeter or Btu heat transfer device, and test specimen. The test stand will include a provision for either moving the burner out of the test position or moving the test specimen into/out of test position. The test stand will also include a provision for positioning the thermocouple rake or burner extension parallel to the burner face with the thermocouple junctions on the diameter or major axis of the burner extension. A suitable test setup is shown in figure E2-1.

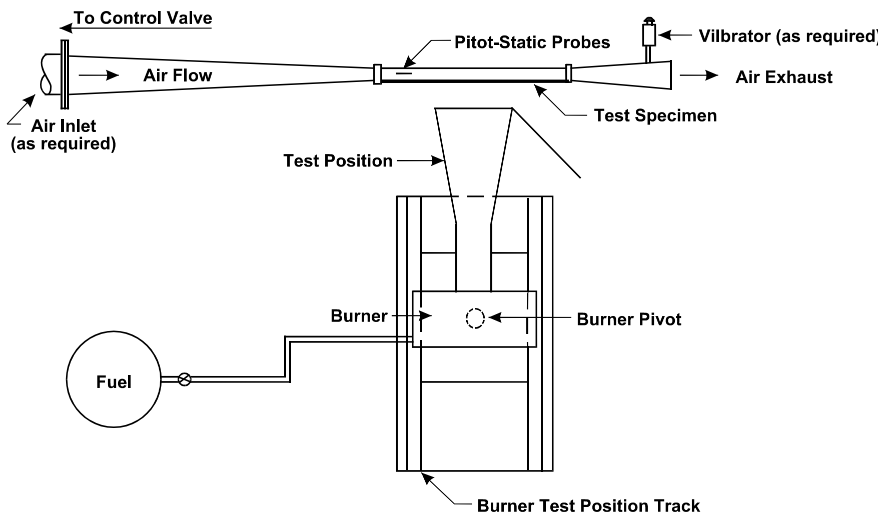


Figure E2-1. Firewall penetration test setup—Top view

E2.3.5 Timer

A stopwatch or other device, calibrated and graduated to the nearest 1 second, will be used to measure the time of application of the burner flame.

E2.4 Test Specimens

E2.4.1 Specimen Selection

Test specimens will be actual or simulated aircraft hardware, including all combustible materials that are applied to the actual structure in use. Heat-flow paths and heat sinks will be as in the production configuration being certified.

E2.4.2 Specimen Size

In general, specimen size will be 24 by 24 inches (610 by 610 mm). Larger specimens will be used if required to accommodate a critical design feature of the component. Smaller specimens of 10 by 10 inches (254 by 254 mm) may be used if all design features are included and the specimen is representative of the intended use. For a smaller specimen, the backside of the specimen will be protected from exposure to the flame.

E2.5 Conditioning

E2.5.1 Specimen Conditioning

Specimens containing nonmetallic components will be preconditioned if required to simulate the aircraft environment.

E2.6 Calibration

E2.6.1 Place the thermocouple rake on the test stand so the rake will be above the centerline of the burner or burner extension exit plane when the burner is in calibration position. Connect the thermocouples to a suitable recorder.

NOTE: If using one of the conversion oil burners described in section 1.1 for this test, the distance used to position the rake, heat-flux measuring device, and test specimen will be 4 inches (101.6 mm) from the burner cone exit. If the burner used is an SAE AS401B Propane Burner, the distance used to position the thermocouple rake may be as close as 2 inches (50.8 mm) from the burner face exit to achieve the temperature and heat-flux density specified in this test procedure.

E2.6.2 Light the burner, allow at least a 5-minute warmup, and move the burner into calibration (see section E2.3.4 for position).

NOTE: If using an SAE AS401B Propane Burner, the flame is not turned off during calibration or test setup. Most test facilities using this burner have provisions for moving the burner in and out of test position. If using a conversion oil burner, most facilities turn the burner on and off to change specimens and calibration equipment. If the burner is turned off at any time, it will be warmed up for a 2-minute period before testing or taking calibration measurements.

E2.6.3 Begin monitoring the temperatures indicated by the thermocouples after 5 minutes. Make adjustments as necessary to either the fuel flow or the airflow to the burner to achieve a minimum average thermocouple reading of 2000°F (1093°C).

E2.6.4 Turn the burner off or move it out of calibration position and remove the thermocouple rake.

E2.6.5 Replace the thermocouple rake with the heat-flux density measuring device. Follow section E2.6.5.1 if using a water-cooled calorimeter for measuring heat-flux density. Follow section E2.6.5.2 if using a Btu heat transfer device for this purpose.

E2.6.5.1 If using the water-cooled calorimeter described in section E2.3.3.2, place the calorimeter at the same distance as the thermocouple rake centered over the burner exit.

NOTE: Operating the calorimeter without water running through it will permanently damage the calorimeter.

E2.6.5.1.1 Light the burner, allowing at least a 2-minute warmup, and move the burner into the calibration position.

E2.6.5.1.2 Measure the heat-flux density continuously or at intervals no greater than 10 seconds. If the heat-flux density is not at least 9.3 Btu/ft-sec (10.6 W/cm) over a 1-minute period, readjust the burner to achieve the proper heat-flux density. If burner adjustments are necessary, remove the heat-flux density measuring device and repeat sections E2.6.1 through E2.6.5.1.2.

E2.6.5.2 If using the Btu heat transfer device described in section E2.3.3.2, ensure the external surface of the copper tubing on the Btu heat transfer device is clean prior to measuring heat flux. Use fine steel wool to clean the copper tubing. Inspect the tubing bore and remove any corrosion/ scale accumulation before each test. A .45-caliber pistol cleaning brush with an extension, or equivalent, has been found suitable for this purpose.

E2.6.5.2.1 The calibration setup is shown in figure E1-4. Provide a 5-foot (1.5-m) constant head of water above the heat-transfer device and a 2-foot (0.61-m) drop to the end of the tailpipe for adjustment of the water flow rate. Use a 1-gallon (3.8-L) measuring container (a container and a weighing scale are also acceptable). Supply water at a temperature of 50° to 70°F (10° to 21°C). Adjust the water flow rate to 500 lb/hr (227 kg/hr) or 1 gal/min (3.8 L/min).

E2.6.5.2.2 Start the water flowing through the Btu heat-transfer device. Center the heat transfer tube in the flame at the same location that the specimen will be placed for testing. Allow at least a 2-minute warmup period to stabilize flame conditions before temperature measurements from the thermometers are recorded.

E2.6.5.2.3 After the warmup period, record the inlet and outlet temperatures every 30 seconds for a 3-minute period. Determine the rate of Btu increase of the water as follows:

Heat transfer = $146 \times (T_o - T_i)$ watts (for Celsius)

= $500 \times (T_o - T_i)$ Btu/hr (for Fahrenheit)

where:

T_o = temperature (°C or °F) at outlet

T_i = temperature (°C or °F) at inlet

E2.6.5.2.4 The heat transfer rate output, as determined by the equation shown in section E2.6.5.2.3, will be a minimum of 4500 Btu/hr (1,314 W). If the heat output from the burner is not above the minimum, make adjustments to the burner and repeat sections E2.6.1 through E2.6.5.2.3.

E2.7 Procedure

In general, tests will be conducted at ambient conditions. However, special airflow/pressure and vibration conditions may be required to simulate the actual aircraft operating environment. Load-carrying specimens will be tested with limit loads applied during the test.

E2.7.1 Light the burner and allow at least a 2-minute warmup.

E2.7.2 Place the test specimen in test position at the same distance from the burner as the thermocouple rake and calorimeter were placed during calibration.

E2.7.3 Start the timer when the test specimen is properly positioned with respect to the burner. The critical or representative area of the test specimen will be aligned with the center of the burner.

E2.7.4 Terminate the test by moving the burner or test specimen out of the test position after 15 minutes, as required for fireproof materials, or after 5 minutes, as required for fire-resistant materials.

E2.7.5 Note the condition of both faces of the test specimen.

E2.7.6 Without making adjustments to the burner flame, repeat the temperature measurements described in sections E2.6.1 through E2.6.3. If the average temperature has decreased by more than 150°F (66°C), readjust the burner and repeat the test with a new specimen.

E2.8 Report

E2.8.1 Fully identify the construction being tested and its use.

E2.8.2 Describe the test apparatus and burner. Include the average flame temperature and heat-flux density (or heat transfer rate) data for pretest calibration and the average temperature for posttest calibration.

E2.8.3 Report the time the specimen is exposed to flame and whether the material or part is fireproof or fire resistant.

E2.8.4 Describe the test specimen before and after testing.

E2.9 Requirements

E2.9.1 No flame penetration will occur for the duration of the test.

E2.9.2 Burning on the backside of the specimen is not acceptable. Significant burning on the side of flame impingement will be investigated to determine if a potential increase in hazard exists. Minor flashing on either side of the specimen is acceptable.

Chapter E3
Test for Electrical Connectors Used in Firewalls

E3.1 Scope

E3.1.1 This test method is intended for use in determining the resistance of high-temperature electrical connectors used in fire zones to damage due to flame and vibration, according to applicable requirements of 14 CFR 23 and 25.

E3.1.2 This test is used to evaluate the capability of wired electrical firewall connectors to prevent flame from passing to the protected side of the firewall. This test provides a means to evaluate the connectors' ability to sustain a minimum current of 1 A for a limited period of time.

E3.1.3 It is suggested that each connector type be tested in three sizes: 22-19, 14-7, and 12-3. Each connector size will be tested separately.

E3.2 Definitions

E3.2.1 Firewall

A firewall is a structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a designated fire zone in which a fire may erupt and cause additional hazard to the aircraft.

E3.2.2 Firewall Connector

A firewall connector is an electrical connector designed for installation in the firewall.

E3.3 Apparatus

E3.3.1 Simulated Firewall

A piece of steel 10 by 10 by 0.063 inches (254 by 254 by 1.6 mm) thick to simulate a firewall will be provided for each of the three connector sizes. A hole will be drilled in the center of each piece appropriate to the respective connector size. If the simulated steel firewall does not adequately represent the actual application, a test of the proposed configuration may be required.

E3.3.2 Burner/Torch

A burner/torch modified to produce and maintain a minimum flame temperature of 2000°F (1093°C) will be provided.

NOTE: An SAE AS401 propane burner or equivalent has been found acceptable.

E3.3.2.1 Burner Fuel

Propane gas fuel of 99 percent minimum purity will be used with a gas flow rate equivalent to 33,000–37,000 Btu/hr.

E3.3.3 Power Supply (Electrical, AC)

A center-tapped transformer will be provided that is capable of producing between 200 V and 260 V (AC) at 400 Hz or 60 Hz and delivering a current of at least 2A.

E3.3.4 Power Supply (Electrical, DC)

A power source will be provided that is capable of producing 28 V direct current (DC) and a current between 5 A and 150 A.

E3.3.5 Current Indicator

A multirange ammeter will be provided that is capable of measuring DC currents between 5 A and 150 A with an accuracy of 1 percent of full scale.

NOTE: Choose the appropriate range of the ammeter to measure the test current. The appropriate range will show the current to be in the middle third of the scale.

E3.3.6 Vibration Source

A means will be provided to vibrate the test fixture vertically at 33 Hz with a total excursion of 0.14 inch (3.6 mm).

E3.3.7 Gas Flowmeter

A gas flowmeter will be provided to measure the fuel flow to the burner/torch.

E3.3.8 Temperature Measuring and Recording Equipment

A temperature sensing system will be provided that includes a thermocouple and a stripchart recorder to monitor the flame temperature.

E3.3.8.1 Thermocouple

An ANSI 22-gauge chromel-alumel (Type K) thermocouple sheathed to a 0.0625-inch (1.6-mm) stainless-steel or inconel tube shall be provided.

E3.3.9 High-Temperature Tape

High-temperature tape, 19 to 25 mm wide, will be provided in sufficient length to wrap over the connector and wire bundles (see section E3.4.2.1).

NOTE: Untreated fiberglass tape has been found satisfactory.

E3.3.10 Test Fixture

A test fixture and setup such as is shown in figure E3-1, including a cable clamp to stabilize the wire bundle connector interface during the test, will be provided.

E3.3.11 Timer

A stopwatch or other device, calibrated and graduated to the nearest 1 second, will be used to measure the time of application of the burner flame.

E3.4 Test Specimens

E3.4.1 Specimen Number

Prepare at least three specimens for each connector shell size to be tested.

E3.4.2 Specimen Preparation

Clean all oil, grease, dirt, and other foreign material from the specimens.

E3.4.2.1 Wrap the plug and receptacle wire bundle with high-temperature tape over the area to be located under the cable clamp that is used to stabilize the wire bundle connector interface during flame/vibration application. This area is a distance of 7.9 ± 0.2 inches (200 ± 5 mm) from the connector backshell. See figures E3-2 and E3-3 for details.

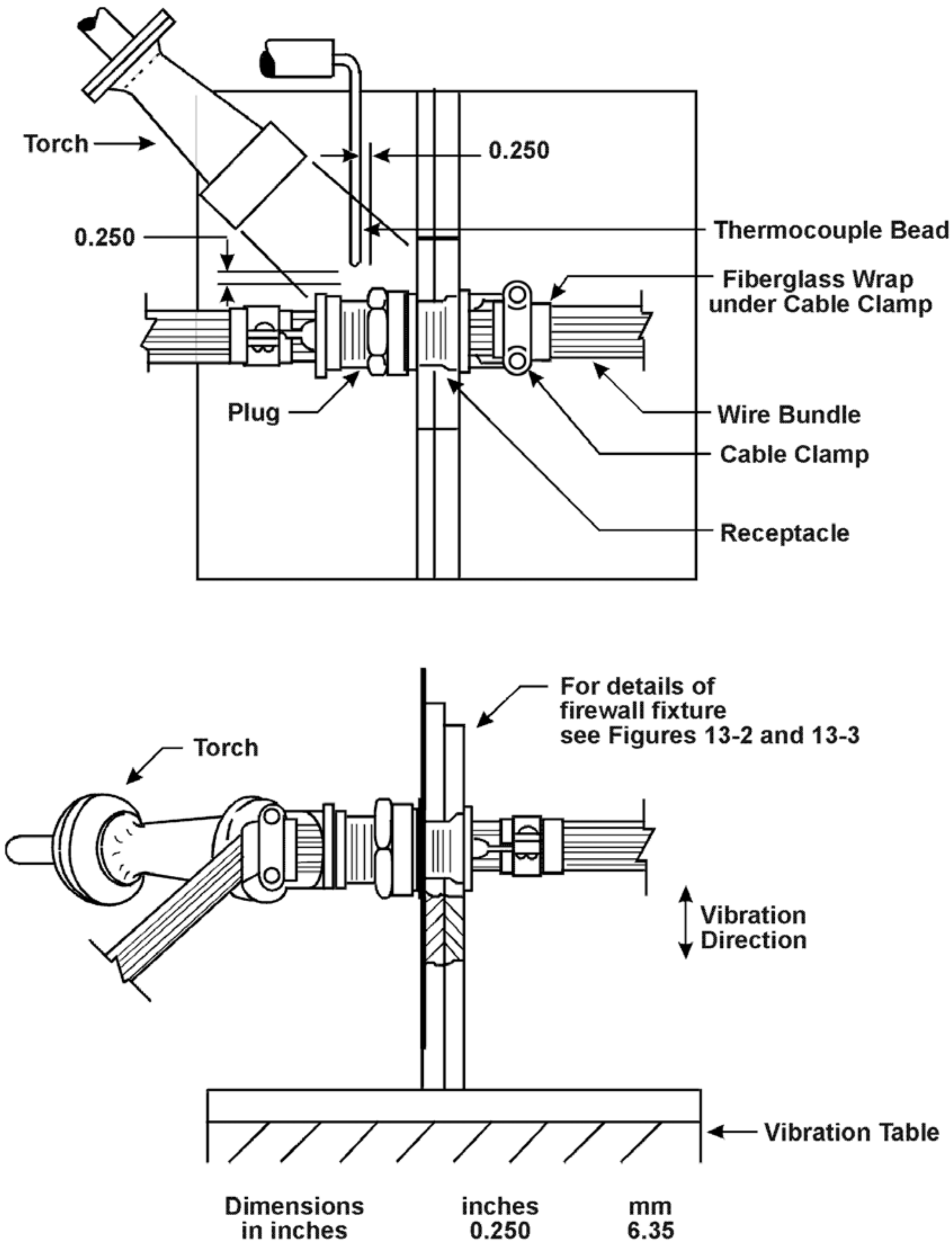
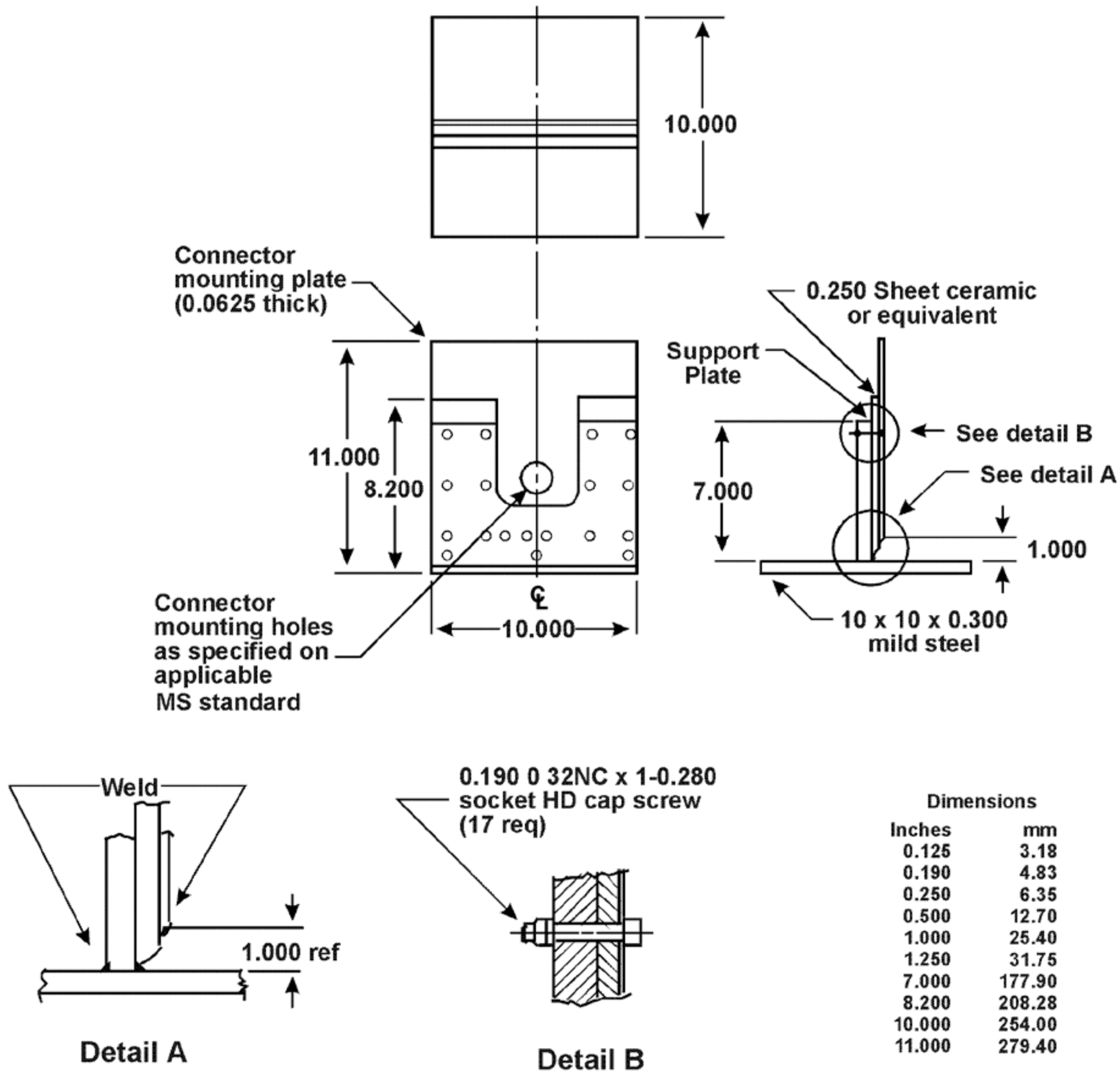


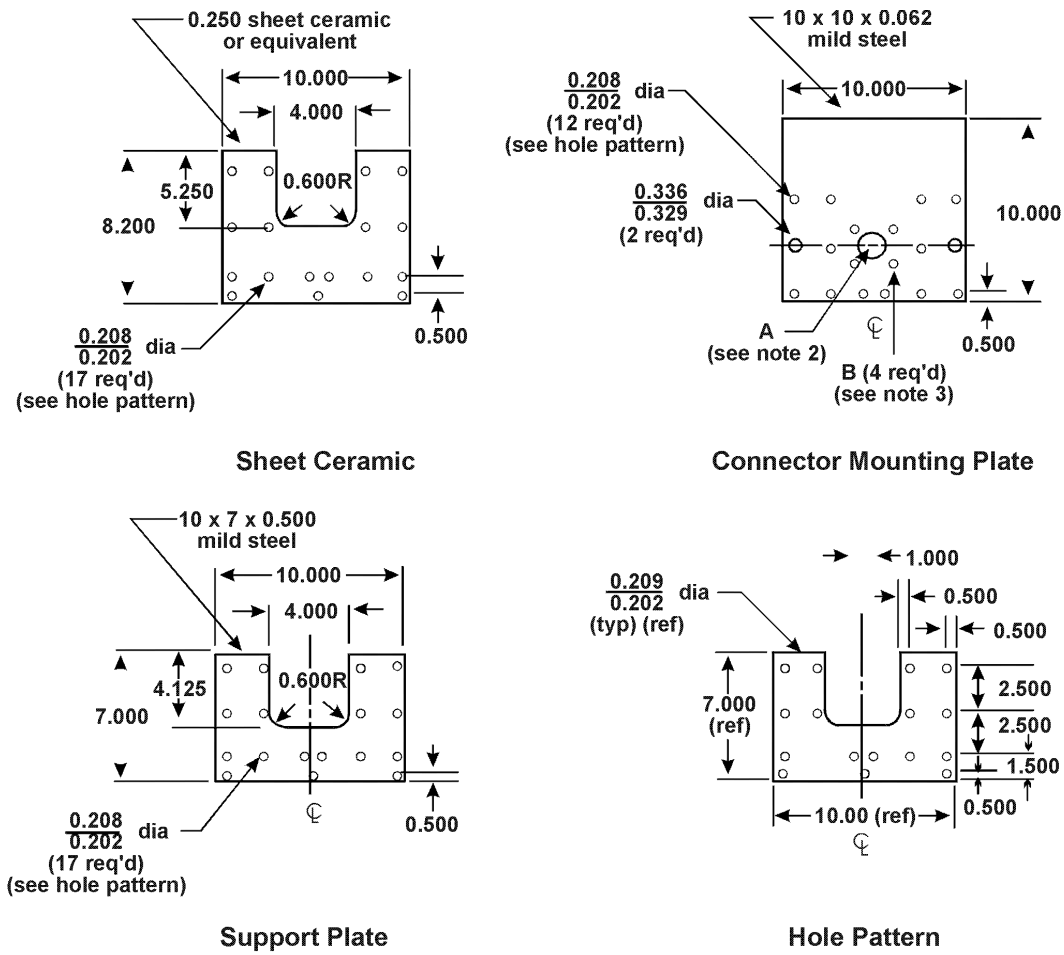
Figure E3-1. Firewall connector test setup



Dimensions

Inches	mm
0.125	3.18
0.190	4.83
0.250	6.35
0.500	12.70
1.000	25.40
1.250	31.75
7.000	177.90
8.200	208.28
10.000	254.00
11.000	279.40

Figure E3-2. Firewall connector fixture assembly



Notes:

1. Dimenstions are in inches. Unless otherwise specified, dimensions symmetrical about centerline.
2. A hole shall provide suitable clearance for the applicable connector.
3. B connector mounting holes shall be as specified on the applicable MS standard.

Inches	mm
0.125	3.18
0.190	4.83
0.250	6.35
0.500	12.70
1.000	25.40
1.250	31.75
7.000	177.80
8.200	208.28
10.000	254.00
11.000	279.40

Figure E3-3. Firewall connector fixture details

E3.4.2.2 Connect the individual wires through the connector such that the circuit will be closed. Ensure that the connector shell is grounded during the test.

E3.5 Procedure

E3.5.1 Test Setup

Mount the simulated firewall on the vibration equipment table. Mount the connector that has been wired, mated, and prepared, as described in sections E3.4.2.1 and E3.4.2.2, in the center of the simulated firewall test fixture.

E3.5.1.1 Support the wire bundle, using clamps to a stationary structure at a distance of 7.9 ± 0.2 inches (200 ± 5 mm) from the connector backshell on each side of the connector to protect from vibration.

E3.5.1.2 Ensure that the connector shell is well grounded prior to starting the test.

E3.5.1.3 Use a circuit for the test designed so that by closing one switch or relay (designated as Switch 2), the connector contacts are connected in series and the direct current potential is applied; by closing another switch or relay (designated Switch 1), the alternating current potential is applied between even- and odd-numbered contacts, as shown in figure E3-4.

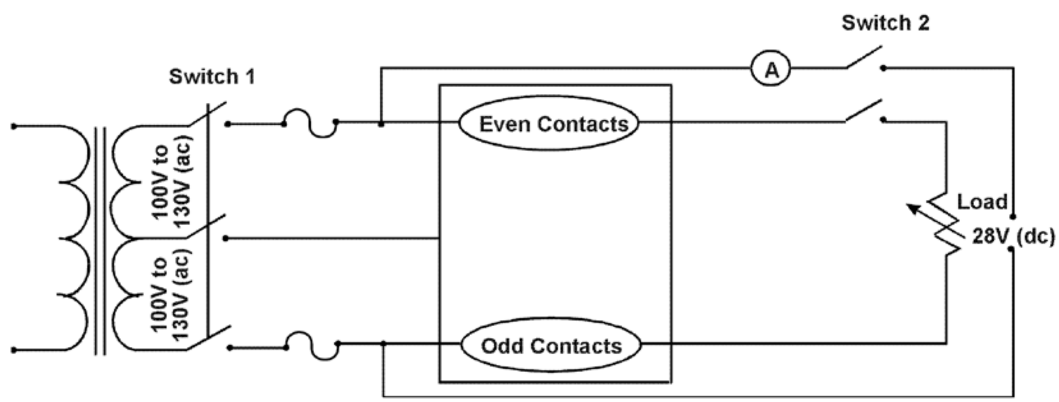


Figure E3-4. Connector electrical integrity connection diagram

E3.5.2 Burner Adjustment

Ignite the burner/torch and adjust the flow of gas and air to obtain a nonoxidizing and nonreducing flame with a flame temperature of 2000° ± 50°F (1093° ± 28°C).

E3.5.3 Test Procedure

E3.5.3.1 Light the burner and stabilize the flame at a minimum temperature of 2000°F (1093°C) for 5 minutes prior to starting the test.

E3.5.3.2 Turn on the vibration source and connect the circuit, as described in section E3.5.1.3.

E3.5.3.3 Simultaneously start the timer and direct the flame at the plug side of the connector test specimen, as shown in figure E3-2, at a distance such that the thermocouple monitoring the temperature is within 0.26 inch (6.5 mm) of the connector. Monitor the temperature of the flame continuously.

E3.5.3.3.1 For the first 5 minutes of the test, connect the contacts in series and load with their rated DC current for the appropriate size contact, as determined by table E3-1. Start the current flow by closing Switch 2. Monitor the current continuously using the ammeter to determine whether the connector circuit retains its conductance.

Table E3-1. Firewall connector test current

Contact Size	Test Current (DC)
22	5
20	7.5
16	13
12	23
8	46
4	80
0	150

E3.5.3.4 At the end of 5 minutes, the difference in potential of the even- and odd-numbered contacts will be 200 V to 260 V (AC), and the difference in potential between the shell and any contact will be 100 V to 130 V (AC). Remove the DC source and break the series connection by closing Switch 1. Immediately after Switch 1 is closed, apply the AC potential by opening Switch 2. Do not allow the circuit to draw a current greater than 2 A. At the end of 1 minute, shut off the current. Observe and record any indication of an increase in current that would show a contact-contact or a contact-shell short circuit.

E3.5.3.5 Continue the flame exposure of the connector until a total of 20 minutes has elapsed, and monitor whether any flame appears on the protected side of the firewall.

E3.6 Report

E3.6.1 Material Identification

Identify the material being tested.

E3.6.2 Flame Penetration

Report whether any flame was detected on the protected side of the firewall during the test.

E3.6.3 Conductivity

Report the minimum current that occurred during the application of electrical power.

E3.6.4 Circuit Integrity

Report any evidence of a contact-contact or a contact-shell short circuit.

E3.7 Requirements

E3.7.1 Flame Penetration

There will be no flame detected on the protected side of the firewall barrier at any time during the 20-minute test.

E3.7.2 Conductivity

The current through the connector during the application of electrical power will not be less than 1 A.

E3.7.3 Circuit Integrity

There shall be no evidence of any contact-contact or contact-shell short circuit.

E3.7.4 Backside Ignition

There shall be no ignition on the backside of the wire bundle.

Chapter E4
Test for Electrical Wire Used in Designated Fire Zones

E4.1 Scope

E4.1.1 This test method is intended for use in determining the resistance of high-temperature electrical wire used in designated fire zones to damage due to flame and vibration, according to the requirements of 14 CFR 25.863, 25.865, 25.867, 25.1201, 25.1203, and 25.1359.

E4.1.2 This test method generally follows MIL-W-25038E. The method is used predominantly in the United States and by most wire and cable manufacturers. ISO/DIS 2685.2 is a similar test procedure and is used by Aerospatiale in France and by the Civil Aviation Authority in the United Kingdom.

E4.2 Definitions

E4.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. In this test, the ignition time is 5 minutes.

E4.2.2 Wire

A single insulated electrical conductor.

E4.2.3 Designated Fire Zone

A region of the aircraft, such as engine and auxiliary power unit compartments, designated to require fire detection and extinguishing equipment and, as appropriate, the use of materials that are fire resistant or fireproof.

E4.2.4 Fire Resistant

Per 14 CFR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “with respect to fluid carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.”

E4.2.4.1 Electrical wire is demonstrated to be fire resistant by meeting the requirements of this 5-minute test.

E4.2.5 Firewall

A structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a designated fire zone in which a fire has erupted and causing additional hazard to the aircraft.

E4.2.6 Fire Zone Wire

A wire installed in a designated fire zone.

E4.3 Apparatus

E4.3.1 Test Fixture

A test fixture, such as shown in figure E4-1, will be provided. The fixture will include a provision for mounting above the test burner.

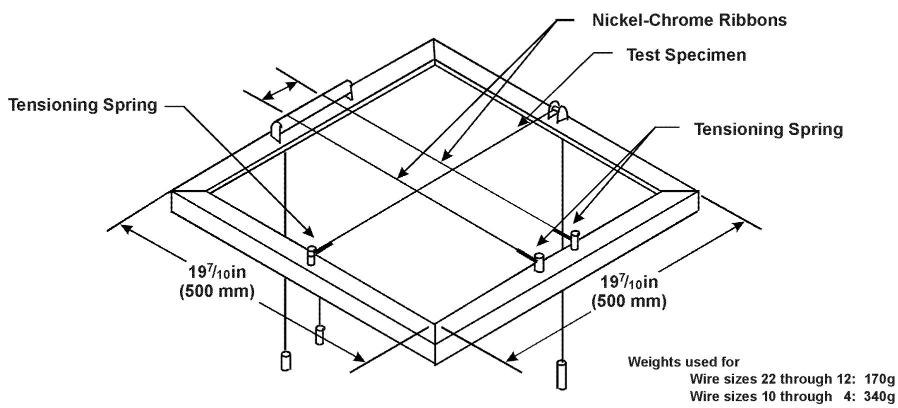


Figure E4-1. Firezone electrical wire test setup

E4.3.2 Test Burner

A test burner, such as shown in figure E4-2, will be provided. The burner will include provisions for introducing air premixed with the gas fuel and for introducing secondary air into the burner flamelets.

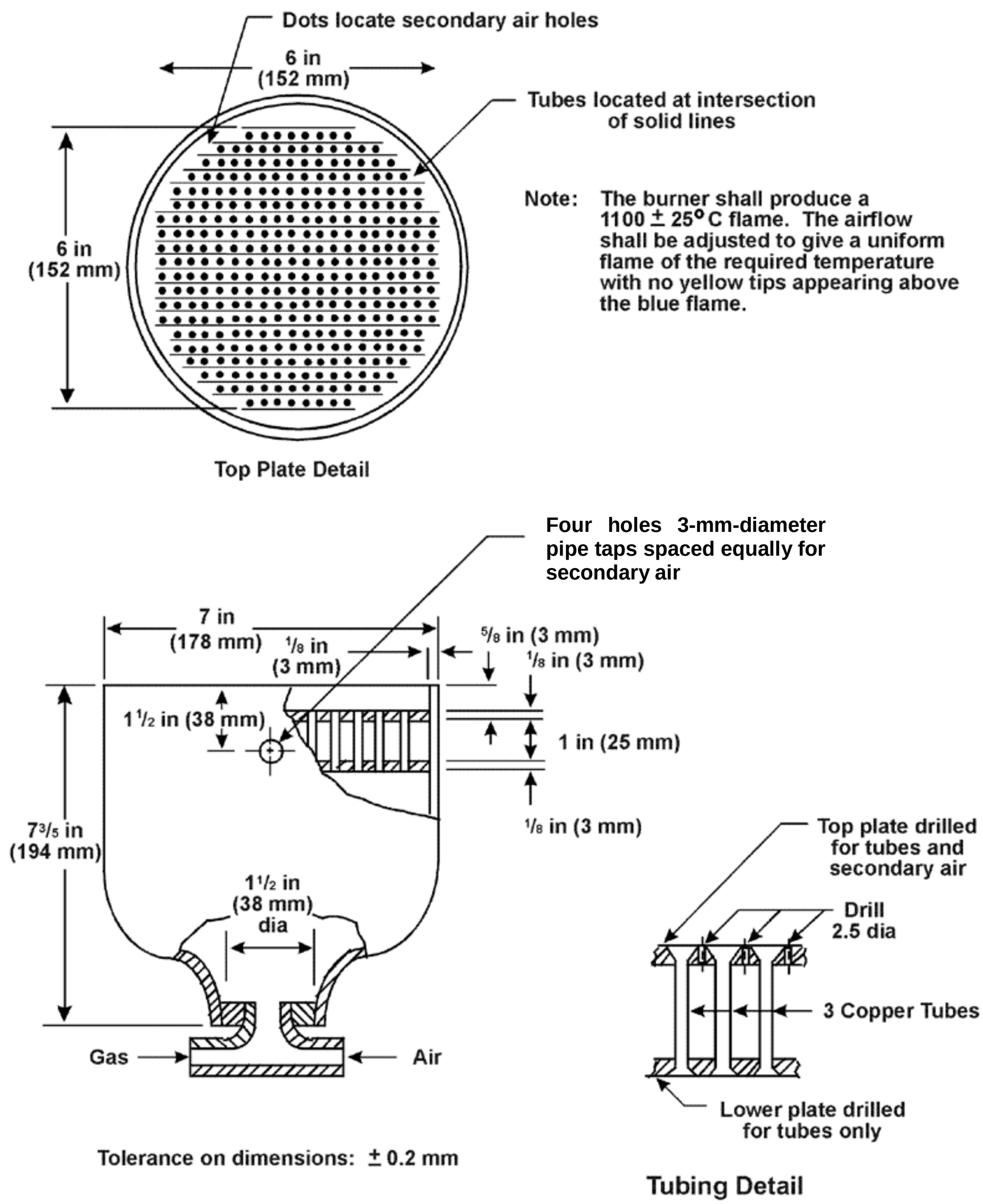


Figure E4-2. Burner details

NOTE: See SAE AS-8028 for burner details.

E4.3.2.1 Burner Fuel

Propane gas of 99-percent purity will be used for the burner fuel.

E4.3.2.2 Plumbing for Gas Supply

The necessary gas connections, tubing, pressure regulators, and gauges will be provided.

E4.3.3 Vibration Source

A means will be provided to vibrate the test fixture vertically at 33 Hz with a total excursion of 0.14 inch (3.5 mm).

E4.3.4 Thermocouple

A 22-gauge ANSI (Type K) chromel-alumel thermocouple or equivalent, as shown in figure E4-3, will be provided to measure the temperature of the burner flame. In addition, a device to continually monitor the thermocouple output within an accuracy of 5 percent will be provided.

E4.3.5 Ammeter

An ammeter will be provided that measures a current of at least 2 A within an accuracy of 5 percent.

E4.3.6 Ohmmeter

An ohmmeter will be provided to measure resistance within an accuracy of 5 percent of full scale.

E4.3.7 Power Source

A power supply will be provided that will deliver 2 A at 115 VAC, 400 Hz, or 60 Hz.

E4.3.8 Nickel-Chrome Ribbons

Two nickel-chrome ribbons that are 0.010 by 0.059 by 23.6 inches (0.25 by 1.5 by 600 mm) will be provided (see figure E4-1).

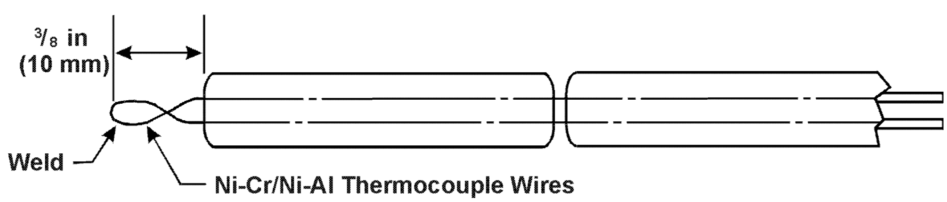


Figure E4-3. Thermocouple details

E4.3.9 Weights

Weights are required to tension the wire over the test fixture. Suggested weights are 12 ounces (340 g) for wire sizes 4–10 and 6 ounces (170 g) for wire sizes 12–22.

E4.3.10 Reagents and Materials

The following materials found in the fire zone of intended use may be necessary to condition the specimens prior to the test:

E4.3.10.1 Aviation fuel such as JP-4 or JP-5 or per MIL-G-5572

E4.3.10.2 Lubricating oil per MIL-L-6082, Grade 1100

E4.3.10.3 Hydraulic fuel per MIL-H-5606

NOTE: The reagents needed for conditioning vary, depending on the airframe manufacturer.

E4.3.11 Timer

A stopwatch or other device, calibrated and graduated to 1 second, will be used to measure the time of application of the burner flame.

E4.4 Test Specimens

E4.4.1 Specimen Length

Specimens will be 24 inches (610 mm) in length.

NOTE: ISO/DIS 2685.2 calls out test specimens that are 30 inches (750 mm) long. MIL-W-25083 calls out test specimens that are 24 inches (600 mm) long. The difference in length does not affect test results.

E4.4.2 Specimen Number

Twelve test specimens will be prepared unless otherwise specified. Three specimens will be tested for each condition: no conditioning, conditioning in aviation fuel, conditioning in hydraulic fuel, and conditioning in lubricating oil (see section E4.5.1).

E4.5 Conditioning/Preparation of Test Specimens

E4.5.1 Test Conditions

Each wire type will be tested without being exposed to any contaminating fluid and after being exposed to each of the fluids described in section E4.3.10. Three test specimens will be used for each of the test conditions.

NOTE: All current industry specifications require only one specimen for each fluid. However, testing three specimens for each fluid will provide a greater degree of confidence in results.

E4.5.1.1 Immerse three test specimens in each test fluid for the times and temperatures shown in table E4-1. Wipe the test specimens with a clean cloth after removing them from the fluids.

Table E4-1. Specimen immersion information

Specimen		Immersion	
No.	Test Fluid	Time (hr)	Temp (°C)
	Mil-G-5572 (grade 100/130)	24	23
1	JP-5	24	23
	JP-4	24	23
2	50% JP-4 and 50% MIL-L-6082	24	23
3	MIOL-L-6082	24	121
4	Skydrol 50084/L04 (aero)	24	23
5	Ethylene Glycol (aero)	24	121

E4.5.1.2 Locate the point on the wire specimen that will be located directly above the center of the burner when the wire specimen is placed on the test stand. Mark a 7-inch-long (178-mm) section with this point in its center by placing a wire band around the specimen 3.5 inches (89 mm) on each side of this point. In addition, place an outer wire band around the test specimen 4 inches (102 mm) outside each of these two bands.

NOTE: The wire band consists of one turn of AWG 30 or smaller wire.

E4.5.2 Store each set of test specimens in a separate airtight container until the time of the test.

E4.6 Calibration

E4.6.1 Position the thermocouple, as shown in figure E4-3, 1 inch (25 mm) above the center of the burner top plate, as shown in figure E4-4.

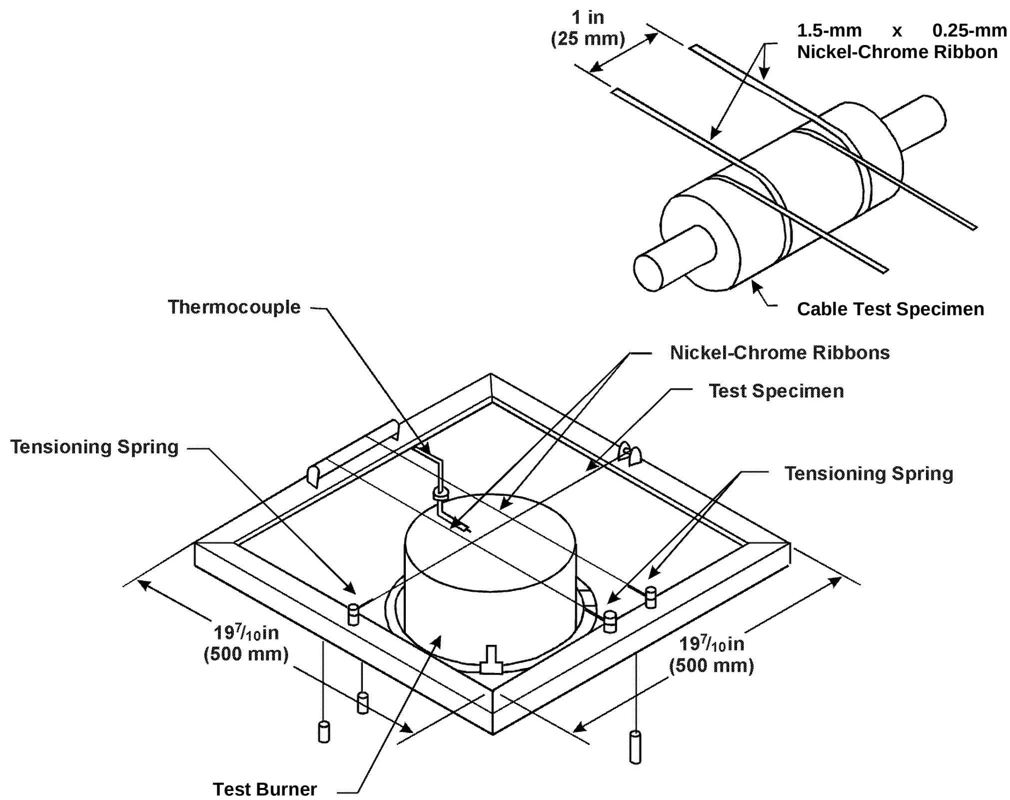


Figure E4-4. Fire-zone electrical wire test setup—Top view

E4.6.2 Ignite the burner and adjust the fuel, air, and secondary air to the burner to obtain a nonoxidizing, nonreducing flame with no yellow tips at a temperature of 2000° ± 50°F (1093° ± 28°C). Stabilize the flame for 5 minutes.

E4.6.3 Turn off the burner after the flame is properly adjusted.

E4.7 Procedure

E4.7.1 Test Setup

Position the test specimen 1 inch (25 mm) above the burner top plate. Place the center 7-inch(178-mm) section of the specimen above the center of the burner (see figure E4-4).

E4.7.1.1 Position the two nickel-chrome ribbons at a distance of 1 inch (25 mm) apart, as measured at the center 7-inch (178-mm) section of the ribbons and perpendicular to the test specimen. Clamp one end of each of the nickel-chrome ribbons to the test fixture. Wrap the nickel-chrome ribbons around the wire and tension with weights. Lock the wires at the pulley, or clamp them to the test fixture. See figure E4-4 for details.

E4.7.1.2 Connect the conductor and the nickel-chrome ribbons as shown in figure E4-5.

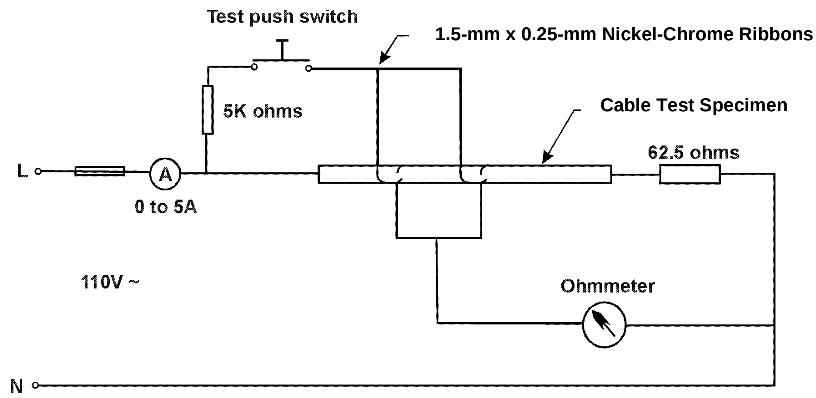


Figure E4-5. Electrical connections

E4.7.1.3 Insert a shorting bar between the conductor and the nickel-chrome ribbons. Adjust the ohmmeter to 0 in this position.

E4.7.1.4 Start the vibration using a frequency of 33 Hz and a vertical amplitude of 0.014 inch (3.5 mm).

E4.7.2 Test Procedure

Start the vibration using a frequency of 33 Hz and a vertical amplitude of 0.014 inch (3.5 mm).

E4.7.2.1 Simultaneously start the timer and apply the ignited burner to the specimen.

E4.7.2.2 Monitor the flame temperature for the duration of the test. Adjust the secondary air continually as necessary to keep the flame and the temperature within the limits specified in section E4.6.2.

E4.7.2.3 Monitor and record the insulation resistance shown by the ohmmeter for the duration of the test, starting at 7.5 seconds after the test begins. In addition, record the lowest resistance shown by the ohmmeter during the test.

E4.7.2.4 Monitor and record the current in the conductor during the test with the ammeter.

E4.7.2.5 Turn off the burner and the vibration, in that order, at the end of the 5-minute test period.

NOTE: Monitoring the conductor has been added in addition to the requirements found in MIL-W-25038. This is done in both the firewall-connector test procedure MIL-STD-1344 test method and the ISO/DIS 2685.2 test procedure for wire. The integrity of the conductor would be as important as the integrity of the insulation if the wire were faced with an inflight fire situation.

E4.8 Report

E4.8.1 Material Identification

Fully describe the wire type being tested. Include manufacturer, manufacturer's product designation, manufacturer's part number, specification callout (if applicable), insulation type, conductor size, and material.

E4.8.2 Insulation Integrity

Report whether the insulation flakes or falls off the conductor.

E4.8.3 Insulation Resistance

Report the insulation resistance at 7.5 seconds into the test, the lowest resistance occurring during the test, and the time of its occurrence.

E4.8.4 Flame Travel

Report whether flame travel on the wire extended beyond the outer marking bands.

E4.8.5 Conductor Amperage

Report the amperage carried through the conductor throughout the duration of the test.

E4.9 Requirements

The following acceptance criteria must be met by each specimen tested.

E4.9.1 Insulation Integrity

The insulation will not flake excessively or fall off the conductor.

E4.9.2 Insulation Resistance

The minimum insulation resistance of the wire under test will be at least 10,000 ohms for the duration of the test.

E4.9.3 Flame Travel

The flame travel on the insulation will not exceed beyond the outer bands.

E4.9.4 Conductor Amperage

The conductor will be able to carry a current of at least 2 A throughout the duration of the test.

APPENDIX A—RESERVED

APPENDIX B—RESERVED

APPENDIX C—RESERVED

APPENDIX D—RESERVED

APPENDIX E—RESERVED

APPENDIX F—LABORATORIES ACTIVELY USING FIRE TEST PROCEDURES

The companies listed in table F-1 (as reported to the FAA) are actively using the fire test procedures in this handbook. This list is not complete or all-inclusive.

Table F-1. Laboratories actively using fire test procedures

LABORATORY/COMPANY NAME	TESTS CONDUCTED
ACES, Inc. 202 N. Park Street P.O. Box 411 Maize, KS 67101 Phone: 316-265-8335 Fax: 316-221-1039 Website: www.aces.aero	Chapters: A1, A6, B1, C1, D1, D2, D3, D4, D5, D6, D13, D14, E2 All tests above available commercially.
Accufleet Testing Services, Inc. 1959 S. Starpoint Drive Houston, TX 77032 Phone: 281-999-8800 Ext. 1111 Email: TEST@AccuFleet.com Website: www.accufleet.com	Chapters: A1, A6, C1, D1, D2, D5, D6, D14 All tests above available commercially.
Aeroblaze Laboratory 12819 Harmon Road, #575 Fort Worth, TX 76177 Phone: 817-668-0628 Email: info@aeroblazelab.com Website: www.aeroblazelab.com	Chapters: A1, C1, D1, D2, D5, D8 All tests above available commercially.
AIM Aerospace Inc. 705 S.W. 7th Street Renton, WA 98057 Phone: 425-235-2750 Fax: 425-228-0761 Website: www.aim-aerospace.com	Chapters: A1, C1, D1, D3, D4 All tests above available commercially.
AIM Composites Limited Pembroke Avenue Waterbeach, Cambridge, CB25 9QR United Kingdom Phone: (44) 1223 441000 Website: www.aimaltitude.com Email: labs@aimaltitude.com	Chapters: A1, C1, D1, D2, D3, D4 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Air Capital Certification Services, Inc. 2946 S. Hydraulic Street Wichita, KS 67216 Phone: 316-524-4466 Fax: 316-524-4455 Email: rclossin@lpesionline@com Website: www.lpesionline.com	Chapters: A1, C1, D1 All tests above available commercially.
Airbus Operations GmbH Department ESCMB2 Fire Safety & Engineering Test Airbus-Allee 1 28199 Bremen, Germany Phone: (49) 421 538 6209/4860 Fax: (49) 421 538 3999/4852 Website: www.airbus.com	Chapters: A1, C1, D1, D2, D3, D4, D5, D6, D9, D13, D14 All tests above available commercially. Chapters: A6, E1, E2, E3, E4 (not offered commercially)
Andrew Muirhead & Son Limited 273-289 Dunn Street Glasgow, Scotland, UK G40 3EA Phone: (44) (0) 141 554 3724 Fax: (44) (0) 141 554 4741 Website: www.muirhead.co.uk	Chapters: A1, D4 All tests above available commercially.
Blue Flame Laboratory 1612 Lima Drive San Luis Obispo, CA 93405-6815 Phone: 805-440-0073 Email: coleeminger@charter.net	Chapters: A1, C1, D1, D2 All tests above available commercially.
Boeing – BR&T HB Boeing Technology Services P.O. Box 3707, MC 1W-02 Seattle, WA 98124-2207 Phone: 206-544-2699 Website: www.boeing.com/bts Email: bts@boeing.com	Chapters: A1, C1, D1, D2 All tests above available commercially.
Boeing Research and Technology Boeing Technology Services P.O. Box 3707, MC 1W-02 Seattle, WA 98124-2207 Phone: 206-544-2699 Website: www.boeing.com/bts Email: bts@boeing.com	Chapters: A1, C1, D1, D2, D3, D4, D7 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Boeing Test and Evaluation Boeing Technology Services P.O. Box 3707, MC 1W-02 Seattle, WA 98124-2207 Phone: 206-544-2699 Website: www.boeing.com/bts Email: bts@boeing.com	Chapters: B1, D5, D6, D14, E2, E4 All tests above available commercially. Chapter: E1 (not commercially available)
CHESTNUT RIDGE FOAM INC. 443 Warehouse Drive Latrobe, PA 15650 Phone: 800-234-2734 Website: www.chestnutridgefoam.com	Chapters: A1, D4, D5 All tests above available commercially.
CREPIM Parc de la Porte Nord Rue Christophe Colomb Bruay-La-Buissiere, France, 62700 Phone: (33) (0) 3 21 61 64 00 Fax: (33) (0) 3 21 61 64 01 Website: www.crepim.fr Email: contact@crepim.fr	Chapters: A1, C1, D1, D2, D4 All tests above available commercially.
CTA, Aeronautical Technologies Center Parque Tecnologico de Alava 01510 Minano, Alava, Spain Phone: (34) 945 296 924 Fax: (34) 945 296 923 Website: www.ctaero.com	Chapters: A1, C1, D1, D2, D3, D4, D5, D6, D13, E2 All tests above available commercially.
Currenta GmbH & Co. OHG Chempark, Geb. B411 D-51368 Leverkusen, Germany Phone: (49) 214 30 34416 Fax: (49) 214 30 96 34416 Website: www.fire-testing.eu Email: brandtechnologie@currenta.de	Chapters: A1, D3, D4 All tests above available commercially.
CUSTOM SCIENTIFIC INSTRUMENTS INC. – CSI Testing Laboratories 1125 Conroy Place Forks Township Easton, PA 18040 Phone: 610-923-6500 Fax: 610-923-6543 Website: www.CSItestlab.com	Chapters: A1, C1, D1, D2, D3, D13, D14 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
DGA Techniques Aeronautiques Centre d'Essais Aeronautiques de Toulouse 47 rue Saint-Jean BP 93123 31131 Balma Cedex, France Phone: (33) 5 6257 5050/5428 Fax: (33) 5 6257 5032	Chapters: A1, C1, D1, D2, D3, D4, D5, D6, D13, D14, E2 All tests above available commercially.
DLR-Material Test Center - Fire Performance Eugen-Saenger-Str. 50 29328 Fassberg, Germany Phone: (49) 551 709 2115 Fax: (49) 551 709 12115	Chapters: A1, B1, C1, D1, D2, D3, D4, D5, D6, D9, E1, E2 All tests above available commercially.
Duncan Aviation, Inc. 15745 S. Airport Road Battle Creek, MI 49015 Phone: 269-969-8400 Fax: 269-968-8273 Website: www.duncanaviation.com	Chapters: A1, B1, C1, D1, D2 All tests above available commercially.
Element Jupiter 15814 Corporate Circle Jupiter, FL 33178 Phone: 561-776-7339 Fax: 561-776-7344 Website: www.element.com	Chapters: E1, E2, E3, E4 All tests above available commercially.
Element Los Angeles 1857 Business Center Drive Duarte, CA 91010 Phone: 818-247-4106 Fax: 818-247-4537 Website: www.delsen.com	Chapters: A1, C1, D1, D2, D3, D4, D9 All tests above available commercially.
Element Minneapolis 9725 Girard Avenue South Minneapolis, MN 55431-2621 Phone: 1-952-888-7795 Fax: 952-888-6345 Website: https://www.elemnent.com/locations/usa/minneapolis	Chapters: A1, C1, D1, D2, E1, E2, E3, E4 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Embraer Engineering and Technology Center 1400 General Aviation Drive Melbourne, FL 32935 Phone: 321-752-8650 Fax: 321-752-3000 Email: russell.wilcken@embraer.com Website: http://embraer.com	Chapters: A1, C1, D1, D2 All tests above available commercially.
Embraer Flammability Laboratory Av. Brigadeiro Faria Lima, 2170 12227-901, Sao Jose dos Campos – SP Brazil Phone: (55) 12 3927 2049 Website: www.embraer.com	Chapters: A1, B1, C1, D1, D2, D3, D4, D5, D6, D8, D9, D13, D14, E1, E2, E3 (no tests offered commercially)
Exova Canada 2395 Speakman Drive Mississauga, Ontario Canada L5K 1B3 Phone: 905-822-4111 Fax: 905-823-1446 Website: www.exova.com Email: sales@exova.com	Chapters: A1, C1, D1, D4, D9 All tests above available commercially.
Exova GmbH Industriepark Hoechst, Building C 369 65926 Frankfurt am Main, Germany Phone: (49) (0) 69 3 05 3476 Fax: (49) (0) 69 3 05 1 70 71 Website: www.exova.com Email: ebh@exova.com	Chapters: A1, C1, D1, D2, D4, D5 All tests above available commercially.
Flame-Tek, LLC 1515 North Center Street, Suite #1 Lonoke, AR 72086 Phone: 208-569-6093 Website: www.flame-tek.com Email: brad.shelton@flame-tek.com	Chapters: A1, C1, D1, D2, D13 All tests above available commercially.
Franklin Products, Inc. 153 Water Street Torrington, CT 06790 Phone: 860-482-0266 Fax: 860-482-6759 Website: www.franklinproducts.net Email: jshailer@franklinproducts.net	Chapter: A1 Test above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
General Plastics Manufacturing Company 4910 Burlington Way Tacoma, WA 98409 Phone: 253-473-5000 Website: www.generalplastics.com Email: tod_maurmann@generalplastics.com	Chapters: A1, C1, D1, D3, D4, D5 All tests above available commercially.
Govmark 96 Allen Boulevard, Suite D Farmingdale, NY 11735-5626 Phone: 631-293-8944 Fax: 631-293-8956 Website: www.govmark.com	Chapters: A1, A6, C1, D1, D2, D3, D4, D5, D6, D8, D9, D13, D14, E2, E4 All tests above available commercially.
Greiner aerospace GmbH Erwin Greiner Strasse 5 4690 Schwanenstadt, Austria Phone: +43 7673 6003-0 Fax: +43 7673 6003 23033 Email: office.at@greiner-aerospace.com Website: www.greiner-aerospace.com	Chapter: A1 (not offered commercially)
Greiner Aerospace Inc. 7621 Pebble Drive, Building 22 76118 Fort Worth, TX, USA Phone: +1 817 686 3100 Fax: +1 817 686 3199 Website: www.greiner-aerospace.com Email: office.us@greiner-aerospace.com	Chapter: A1 (not offered commercially)
Greiner Aerospace CZ spol s r.o. Komenského 895 340 22 Nýrsko, Czech Republic Phone: +420 376 804 120 Fax: +420 376 804 Website: www.greiner-aerospace.com Email: office.cz@greiner-aerospace.com	Chapter: A1 (not offered commercially)

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Greiner Aerospace (Shanghai) Ltd. Building 13/C2, No. 260, Liancao Rd, Minhang District, Shanghai 201108 P.R. China Phone: +86 21 6434 0300 Fax: +86 21 6434 5550 Website: www.greiner-aerospace.com Email: office.cn@greiner-aerospace.com	Chapter: A1 (not offered commercially)
HAECO Americas Cabin Solutions 5568 Gumtree Road Winston-Salem, NC 27107 Phone: 336-464-0122 Website: www.haeco.aero	Chapters: A1, D1, D2, D3, D4, D5 All tests above available commercially.
Heath Tecna Inc. 3225 Woburn Street Bellingham, WA 98226 Phone: 360-738-2005 Fax: 360-715-3999	Chapters: A1, C1, D1, D2, D3, D4 All tests above available commercially.
Herb Curry Inc. 1701 Leonard Road P.O. Box 753 Mt. Vernon, IN 47620 Phone: 812-838-6703 Fax: 812-838-6712	Chapters: A1, C1, D1, D3, D4 All tests above available commercially.
INDUSTRIAL NEOTEX S.A. C/Forjadores, Parcela 17-11 Pol. Ind. Prado del Espino Boadilla del Monte (Madrid), 28660, Spain Phone: (34) 916 324 391 Fax: (34) 916 324 284 Website: www.neotex.com Email: aha@neotex.com	Chapters: A1, D5 All tests above available commercially.
ISOVOLTA AG 2355 Wiener Neudorf Austria Phone: (43) 5 9595 9305 Fax: (43) 5 9595 79305 Website: www.isovolta.com	Chapters: A1, C1, D1, D3, D4 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Isovolta, Inc. 495 Territorial Street P.O. Box 287 Harrisburg, OR 97446 Phone: 541-995-6395 Fax: 541-995-8425 Website: www.isovolta-or.us	Chapters: A1, C1, D3, D4 All tests above available commercially.
Jamco Singapore Pte Ltd No. 8 Loyang Lane Singapore 508915 Phone: (65) 6417 0560 Fax: (65) 6542 0248 Website: www.sinjam.com.sg	Chapters: A1, C1, D1, D3, D4, D5, D13 All tests above available commercially.
Krueger Testing and Consulting 14402 E. Goodwin Road Stanwood, WA 98292 Phone: 360-631-6167 Website: www.kruegerflam.com Email: keith@kruegerflam.com	Chapters: A1, C1, D1, D2, D3, D4, D13 All tests above available commercially.
Lantal Textiles Dorfgasse 5 P.O. Box 1330 4901 Langenthal, Switzerland Phone: (41) 62 916 71 06 Fax: (41) 62 923 25 32 Website: www.lantal.com	Chapters: A1, C1, D1, D3, D4, D5, D8 All tests above available commercially.
L.E.F.A.E. (Laboratoire d'essais feu aéronautiques et életriques 9 Route du Dome 69630 Chaponost, France Phone: (33) 43 720 1917 Fax: (33) 43 720 1910 Website: www.lab-lefae.com Email: a.gutierrez@lab-lefae.com	Chapters: A1, C1, D1, D2, D3, D4, D5, D6, D8, D10, D14, E1, E2, E3, E4 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Lufthansa Technik AG Central Laboratory Services Materials Flammability Test Center HAM TQ/M-C Weg beim Jaeger 193 22335 Hamburg, Germany Phone: (49) 40 5070 3792 URL: www.Lufthansa-technik.com/de/laboratory-services Email: laboratoryservices@lht.dlh.de	Chapters: A1, B1, C1, D1, D2, D3, D8 All tests above available commercially.
MTI Polyfab, a 3M Company 7381 Pacific Circle Mississauga, L5T 2A4, Ontario, Canada Phone: 905-564-9700 x7280 Fax: 905-564-8886 Website: www.mmm.com Contact: Tatjana Stecenko Email: tstecenko@mmm.com	Chapters: A1, D13, D14 All tests above available commercially.
Parker Hannifin Corporation-Stratoflex Products Division 2575 West 5th Street Jacksonville, FL 32254 Phone: 904-389-3400 Fax: 904-384-5874	Chapter: E1 (not offered commercially)
Parker Hannifin Corporation-Stratoflex Products Division 220 Roberts Cutoff Road Fort Worth, TX 76114 Phone: 817-738-6543 Fax: 817-738-9920	Chapter: E1 (not offered commercially)
Resonate Testing Limited Unit 1, Bridge Technology Park Carnagat Lane Newry, BT35 8XF United Kingdom Phone: 44 (0) 2890 736 390 Website: www.resonatetesting.com Email: info@resonatetesting.com	Chapters: A1, A6, C1, D1, D2, D5, D6, D14, E1, E2 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
RESCOLL Technical Centre of Materials 8 Allee Geoffroy St, Hilaire 33615 Pessac, France Phone: (33) 547 74 69 00 Website: www.rescoll.fr Email: rescoll@rescoll.com	Chapters: A1, C1, D1, D2, D3, D4, D5, D6, D13, E2 All tests above available commercially.
Schneller Inc. Corporate Office 6019 Powdermill Road Kent, OH 44240 Phone: 330-676-7156 Fax: 330-673-6374 Website: www.schneller.com	Chapters: A1, D3, D4 All tests above available commercially.
Sibir Technics LLC Flammability Test Laboratory Ob Town-2, Novosibirsk Region Russian Federation, 633102 Phone: +7 (383) 3599 013 Fax: +7 (383) 3599 048 Website: www.engineering.-ru.com Email: FTL@e-mro.aero	Chapters: A1, C1, D1, D2, D5 All tests above available commercially.
Skandia, Inc. 5000 North Highway 251 Davis Junction, IL 61020 Phone: 815-393-4600 Fax: 815-393-3501 Website: www.skandia-inc.com	Chapters: A1, B1, C1, D1, D2, D3, D4, D5, D7, D9, D13 All tests above available commercially.
Starr Aircraft Products, Inc. 5236 North Hwy 1417 Sherman, TX 75092 Phone: 903-893-1106 Fax: 903-893-0551 Website: www.starraircraft.com Email: bstrobl@starraircraft.com	Chapters: A1, D5 All tests above available commercially.
Tapis Corporation 1121 Roundtable Drive Dallas, TX 75247 Phone: 214-631-9700 Website: www.tapiscorp.com Email: info@tapiscorp.com	Chapters: A1, C1, D1, D2, D3, D4 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Test Center of Civil Aviation Administration of China (CAAC) No. 17, South Section 2, 2nd Ring Road Chengdu, P.R. China 610041 Phone: 0086-28-64456066, or 0086-28-64456022 Fax: 0086-28-64456010 Website: www.fccc.org.cn	Chapters: A1, B1, C1, D1, D2, D3, D4, D5, D6, D8, D9, D13, D14, E2 All tests above available commercially.
Testcorp 24662 Rhea Drive Mission Viejo, CA 92691 Phone: 949-859-3569 Website: www.testcorp.net Email: jnauman@testcorp.net or mnauman@testcorp.net	Chapters: A1, C1, D1, D2, D3, D4, D13 All tests above available commercially.
Triumph Composite Systems, Inc. 1514 S. Flint Road Spokane, WA 99219 Phone: 509-623-8100 Fax: 509-623-8099 Website: www.triumphgroup.com	Chapters: A1, C1, D13 All tests above available commercially.
TTF Aerospace LLC 4620 B St NW Suite 101 Auburn, WA 98001 Phone: 253-736-6300 Fax: 253-250-6825 Website: www.ttfaero.com Email: sales@ttfaero.com	Chapters: A1, B1, C1, D1, D2, D3, D4, D9 All tests above available commercially.
University of Cincinnati, Fire Test Center 5997 Center Hill Avenue, Building A Cincinnati, OH 45224 Phone: 513-641-3041/513-556-5743 Fax: 513-556-5038 Email: firetest@uc.edu Website: http://cfrl.uc.edu/ftc-index.html	Chapters: E1, E2
Vauth & Sohn GmbH Hembser Str. 1 33034 Brakel, Germany Phone: (49) 5272 3713-0 Fax (49) 5272 6671 Website: www.vauth-sohn.com	Chapters: A1, C1, D1, D2, D4, D5 All tests above available commercially.

Table F-1. Laboratories actively using fire test procedures (continued)

LABORATORY/COMPANY NAME	TESTS CONDUCTED
Zodiac Aerospace – Sell GmbH Dr.-Siegfried-Strasse D-35745 Herborn Germany Phone: (49) 2772 707 802 Fax: (49) 2772 707 133 Website: www.-sell-interiors.com	Chapters: A1, B1, C1, D1, D2, D3, D4 All tests above available commercially.

LEGEND FOR TABLE F-1 AIRCRAFT MATERIALS FIRE TEST HANDBOOK CHAPTERS

A Post Crash Tests

Chapter A1: Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials

Chapter A2: Radiant Heat Testing of Evacuation Slide Materials (using power methodology to calibrate heater)

Chapter A3: Oil Burner Test for Seat Cushions (sonic burner)

Chapter A4: Heat Release Rate Test for Cabin Materials (HR2)

Chapter A5: Test Method to Determine the Burnthrough Resistance of Thermal/Acoustic Insulation Materials (sonic burner)

Chapter A6: Oil Burner Flammability Test for Magnesium Alloy Seat Structure

B In-Flight Tests

Chapter B1: Fire Containment Test of Waste Stowage Compartments

Chapter B2: Test Method to Determine the Flammability and Flame Propagation Characteristics of Thermal/Acoustic Insulation Materials

Chapter B3: VFP for Composite Structure

Chapter B4: VFP for Ducting

Chapater B5: VFP for Wiring

Chapter B6: Test Method to Determine the Flammability Characteristics of Magnesium Alloy

C Required Cargo Compartment Tests

Chapter C1: 45-Degree Bunsen Burner Test for Cargo Compartment Liners and Waste Stowage Compartment Materials

Chapter C2: Oil Burner Test for Cargo Liner (sonic burner)

D Optional Tests

Chapter D1: Horizontal Bunsen Burner Test for Cabin, Cargo Compartment, and Miscellaneous Materials

Chapter D2: 60-Degree Bunsen Burner Test for Electric Wire

Chapter D3: Heat Release Rate Test for Cabin Materials

Chapter D4: Smoke Test for Cabin Materials

Chapter D5: Oil Burner Test for Seat Cushions

Chapter D6: Oil Burner Test for Cargo Liners

Chapter D7: Radiant Heat Testing of Evacuation Slide Materials

Chapter D8: Recommended Procedure for the Four-Ply Horizontal Flammability Test For Aircraft Blankets

Chapter D9: Smoke Test for Insulated Aircraft Wire

Chapter D10: Dry Arc Tracking Procedure

Chapter D11: Dry Arc-Propagation Resistance

Chapter D12: Cotton Swab Test for Thermal Acoustic Insulation Blankets

Chapter D13: Test Method To Determine the Flammability and Flame Propagation Characteristics of Thermal/Acoustic Insulation Materials

Chapter D14: Test Method To Determine the Burnthrough Resistance of Thermal/Acoustic Insulation Materials

E Powerplant Tests

Chapter E1: Powerplant Hose Assemblies Test

Chapter E2: Powerplant Fire Penetration Test

Chapter E3: Test for Electrical Connectors Used in Firewalls

Chapter E4: Test for Electrical Wire Used in Designated Fire Zones

APPENDIX G—COMMERCIAL MANUFACTURERS OF FIRE TEST EQUIPMENT

The following companies (as reported to the FAA) manufacture test/calibration equipment used to conduct the fire tests described in this handbook.

Table G-1. Commercial manufacturers of fire test equipment

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Test Chamber used for Vertical, Horizontal, and 45-Degree Bunsen Burner Test described in Chapters A1, C1, D1, D2, and D8.	Atlas Material Testing Technology 1500 Bishop Court Mount Prospect, IL 60056 Phone: 773-327-4520/Fax: 773-327-5787 Email: info@atlas-mts.com URL: http://www.atlas-mts.com Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk Fire Testing Technology Limited Charlwoods Road, East Grinstead, West Sussex, RH19 2HL, United Kingdom Tel: +44 (0)1342 323600 Fax:+44 (0)1342 323608 E-mail: sales@fire-testing.com URL: www.fire-testing.com GBH International 2 Friars Lane Mill Valley, CA, 94941 Phone: 415-388-8278/FAX: 415-795-9618 Email: sales@gbhinternational.com URL: www.gbhinternational.com Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Test Chamber used for Vertical, Horizontal, and 45-Degree Bunsen Burner Test described in Chapters A1, C1, D1, D2, and D8.	Custom Scientific Instruments, Inc. 1125 Conroy Place Forks Industrial Park IV Easton, PA 18040 Phone: 610-923-6500 Fax: 610-923-6543 URL: http://www.csi-instruments.com Marlin Engineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com Thermtech Industries LLC 8526 South Elwood Tulsa, OK 74132 Phone: 918-630-3659 Email: sales@thermtechindustries.com URL: http://www.thermtechindustries.com
Rate of Heat Release Apparatus described in Chapter D3.	Fire Testing Technology Limited Charlwoods Road, East Grinstead, West Sussex, RH19 2HL, United Kingdom Tel: +44 (0)1342 323600 Fax:+44 (0)1342 323608 E-mail: sales@fire-testing.com URL: www.fire-testing.com GBH International 2 Friars Lane Mill Valley, CA, 94941 Phone: 415-388-8278/FAX: 415-795-9618 Email: sales@gbhinternational.com URL: www.gbhinternational.com Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
	Custom Scientific Instruments, Inc. 1125 Conroy Place Forks Industrial Park IV Easton, PA 18040 Phone: 610-923-6500 Fax: 610-923-6543 URL: http://www.csi-instruments.com MarlinEngineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com
Smoke Density Chamber described in Chapters D4 and D9.	Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk Fire Testing Technology Limited Charlwoods Road, East Grinstead, West Sussex, RH19 2HL, United Kingdom Tel: +44 (0)1342 323600 Fax:+44 (0)1342 323608 E-mail: sales@fire-testing.com URL: www.fire-testing.com GBH International 2 Friars Lane Mill Valley, CA, 94941 Phone: 415-388-8278/FAX: 415-795-9618 Email: sales@gbhinternational.com URL: www.gbhinternational.com Newport Scientific, Inc. 8246-E Sandy Court Jessup, MD 20794 Phone: 301-498-6700/Fax: 301-490-2313 Email: newport888@aol.com URL: http://www.newport-scientific.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Smoke Density Chamber described in Chapters D4 and D9.	Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com MarlinEngineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com
Water-cooled calorimeter described in Chapters D3, D6, D7, E1, and E2.	Medtherm Corporation 2604 Newby Road Huntsville, AL 35805 Phone: 256-837-2000/Fax: 256-837-2001 Email: medthermco@aol.com URL: http://www.metherm.com Vatell Corporation 240 Jannelle Road Christiansburg, VA 24073 Phone: 540-961-3576/Fax: 540-953-3010 Email: mkt@vatell.com URL: http://www.vatell.com (Supplier of Thermogage™ products for heat-flux sensing and calibration).
Insulation/backing material used for specimen preparation, calorimeter mounting, baffle, described in Chapters D3, D4, D5, D6, E1, and E2.	Thermal Ceramics 2102 Old Savannah Road Augusta, GA 30906 Phone: 706-796-4200/Fax: 706-976-4398 Email: tceramics@thermalceramics.com URL: http://www.morganthermalceramics.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Oil Burner Test Rigs described in Chapters D5, D6, and E2.	Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com MarlinEngineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com
Aircraft Blanket Tester described in Chapter D8.	Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com Fire Testing Technology Limited Charlwoods Road, East Grinstead, West Sussex, RH19 2HL, United Kingdom Tel: +44 (0)1342 323600 Fax:+44 (0)1342 323608 E-mail: sales@fire-testing.com URL: www.fire-testing.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Aircraft Blanket Tester described in Chapter D8.	GBH International 2 Friars Lane Mill Valley, CA, 94941 Phone: 415-388-8278/FAX: 415-795-9618 Email: sales@gbhinternational.com URL: www.gbhinternational.com
Radiant Heat Panel Test Apparatus described in Chapter D13.	Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk Fire Testing Technology Limited Charlwoods Road, East Grinstead, West Sussex, RH19 2HL, United Kingdom Tel: +44 (0)1342 323600 Fax:+44 (0)1342 323608 E-mail: sales@fire-testing.com URL: www.fire-testing.com GBH International 2 Friars Lane Mill Valley, CA, 94941 Phone: 415-388-8278/FAX: 415-795-9618 Email: sales@gbhinternational.com URL: www.gbhinternational.com Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com MarlinEngineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Sonic Burner Test Rig described in Chapter D14.	Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk Govmark 96-D Allen Boulevard Farmingdale, NY 11735-5626 Phone: 631-293-8944/Fax: 631-293-8956 Email: info@govmark.com URL: http://www.govmark.com MarlinEngineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com Custom Scientific Instruments, Inc. 1125 Conroy Place Forks Industrial Park IV Easton, PA 18040 Phone: 610-923-6500 Fax: 610-923-6543 URL: http://www.csi-instruments.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com
Sonic Burner for Magnesium Alloy Seat Component Test as described in Chapter A6.	MarlinEngineering, Inc. 2200 Division Street, Suite A Bellingham, WA 98226 Phone: 360-671-0155 Email: sales@marlinengineer.com URL: http://www.marlinengineer.com Deatak 4004 W. Dayton Street McHenry, IL 60050 Phone: 815-322-2013 Fax: 815-679-6544 Email: instruments@deatak.com URL: www.deatak.com

Table G-1. Commercial manufacturers of fire test equipment (continued)

EQUIPMENT DESCRIPTION	SUPPLIER/MANUFACTURER
Sonic Burner for Magnesium Alloy Seat Component Test as described in Chapter A6.	Concept Equipment Ltd. Unit D1, Rustingtion Trading Estate, Dominion Way West Sussex, BN16 3HQ, United Kingdom Phone: 44 (0) 1903 784336 Email: fire@concept-e.co.uk URL: www.concept-e.co.uk

APPENDIX H—AVIATION HEAT-FLUX CALIBRATION STANDARD, INCLUDING SPECIFICATION, CALIBRATION SETUP, AND PROCEDURE

H.1. SCOPE

H1.1 APPLICABILITY

This document describes a standardized approach for transferring National Institute of Standards and Technology (NIST) primary heat-flux calibrations to total heat flux gauges (HFG) used in flammability testing of aircraft materials. An apparatus consisting of a reference HFG, a radiant heat source capable of producing flux levels up to 5 W/cm^2, and a precision alignment system are required.

H.2. DEFINITIONS

H.2.1 CALIBRATION FACTOR (SCALE FACTOR)

The calibration factor is a constant multiplier that converts an HFG's millivolt signal to the measured value of heat flux. It is derived from incident flux (W/cm^2 or BTU/ft^2*sec)/Sensor Output (mV). The responsivity or sensitivity is the reciprocal of the calibration factor.

H.2.2 HEAT FLUX

The rate of thermodynamic energy transfer per unit area that is incident on a material (W/cm^2 or BTU/ft^2*sec).

H.2.3 HFG

A transducer used in determining heat-flux levels (see Section H.3).

H.2.4 HFG CALIBRATION HIERARCHY

NIST (Primary) → Secondary Standard HFG → Transfer Standard HFG → Working HFG

H.2.5 NIST

NIST (USA) is considered the owner of the Primary Heat Flux Standard.

H.2.6 SECONDARY STANDARD HFG

The Secondary Standard HFG is calibrated by NIST using their heat-flux calibration service. This gauge is used to transfer NIST calibration values to a Transfer Standard HFG.

H.2.7 STANDARDIZED HFG

A Secondary Standard HFG or a Transfer Standard HFG are considered to be Standardized HFGs.

H.2.8 TRANSFER STANDARD HFG

The Transfer Standard HFG is calibrated by a Secondary Standard HFG. This gauge is used to transfer NIST calibration values to a Working HFG.

H.2.9 WORKING HFG

A HFG received from a testing facility to be calibrated. This gauge is used for setting heat-flux levels in day to day laboratory flammability testing.

H.3. HFG SPECIFICATION

H.3.1 TYPE

A Gardon or Schmidt-Boelter HFG

H.3.2 FULL SCALE RANGE (NOMINAL)

0 – 5 W/cm^2 (0–4.4 BTU/ft^2*sec)

H.3.3 CONSTRUCTION

The HFG shall be continuously water-cooled and cylindrical in shape, having a 1-inch (25.4 mm) diameter body. A mounting flange attached to the body is permissible. Cooling water tubing length and diameter may vary.

H.3.4 COATING

The HFG must have a thin, full-faced, opaque coating of high-quality, high-temperature, ultra-flat black paint having a diffuse surface finish (see figure H-1). To better obtain an ultra-flat finish, several very light coats of paint are sprayed on the sensor face and permitted to dry between coatings. If sprayed until wet, the binder agent may puddle, engulfing suspended particles (typically carbon) and therefore making the surface appear shiny even when dry.

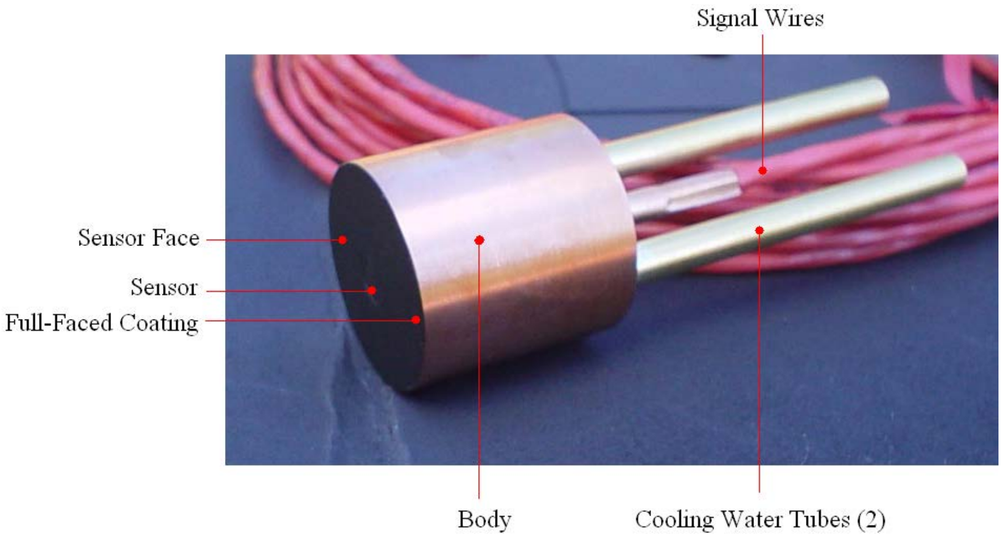


Figure H-1. HFG diagram

Repeat application until the surface is completely covered. The nominal dry film thickness of the coating on the sensor face must be 5 mils or less with the "orangey" copper face of the sensor not visible.

The coating on the HFG to be calibrated must be removed and replaced prior to calibration.

NOTE: Mankiewicz Black Suede, Krylon Flat Black, Pyromark 1200 Flat Black paints or products of similar specification or function have been found suitable.

H.3.5 COOLING WATER

The HFG cooling water temperature, pressure, and flow are maintained within the manufacturer's recommendations. It is not recommended to connect cooling water circuits in series.

H.4. DATA-ACQUISITION SYSTEM SPECIFICATION

The data-acquisition system must have a minimum scan rate frequency of 4 Hz, a measurement uncertainty less than ± 0.01 mV (at 95% confidence, k=2), and be able to collect the two HFG signals within 0.1 seconds of each other. The data-acquisition system must be calibrated annually to NIST traceability.

The calibration software must convert millivolt data of a Working HFG (gauge to be calibrated) to that of a Standardized gauge (having a known slope) to generate a calibration factor. Calibration data between the range of 1 W/cm^2 (0.88 BTU/ft^2*sec) and 4 W/cm^2 (3.52 BTU/ft^2*sec) is used to linearize the slope. Zero offset data are not to be considered, and data beyond these two ranges must be omitted.

H.5. CALIBRATION INTERIM

H.5.1 SECONDARY STANDARD HFG

The Secondary Standard HFG must be calibrated at NIST using their heat-flux calibration service at least once every 5 years. This HFG should not be used for anything other than calibrating transfer standard sensors.

H.5.2 TRANSFER STANDARD HFG

The Transfer Standard HFG must be calibrated by a Secondary Standard HFG at least once every year.

H.5.3 WORKING HFG

The Working HFG must be calibrated by a Standardized HFG at least once every year.

H.5.4 DATA-ACQUISITION SYSTEM

The data-acquisition system must be calibrated to NIST traceable voltage sources at least once every year.

H.6. LABORATORY ENVIRONMENT

The air circulating around the apparatus must be draft-free (stagnant). The ambient laboratory dew point must be lower than 5° below the cooling water temperature (for example, at 73°F [23°C], the ambient relative humidity shall be less than 80 percent to achieve this). This is to prevent condensation from forming on the sensor face.

H.7. CALIBRATION SETUP

H.7.1 METHOD

The HFG is calibrated for incident heat flux in the vertical orientation, as show in figure H-1. Radiant heat is applied to both sensors simultaneously to achieve a near full-scale output. Both HFGs must be monitored to ensure units are not driven over the full-scale range, resulting in potential damage or loss of calibration. Data used in determining the calibration factor are recorded during the cool-down period of calibration.

H.7.2 GAUGE TYPE

When transferring a calibration from a standardized gauge to a non-standardized gauge, both gauges do not have to be of the same type (see Section H.3.1).

H.7.3 MOUNTING HFGS FOR CALIBRATION

When securing the cylindrical 1-inch body of the instruments into position for calibration, avoid obstructing the sensors’ 180-degree field of view of the radiant heat source.

H.7.4 MOUNTING FIXTURE

If more than one HFG mounting fixture is used, they must be identical in construction.

H.7.5 HFG POSITIONING

Mount a Standardized HFG and the unit to be calibrated in the vertical orientation (see figure H-1). Each gauge must be located a minimum of 0.375 inch (10 mm) to the radiant heat source. They must be equidistant or within 0.002 inch (0.05 mm) of each other with the sensor facing parallel to the heating elements. Use extreme care when setting the distance from the radiant heat source by avoiding contact with sensor face.

H.7.6 COOLING WATER

Ensure there is proper water flow to each sensor before initiating the HFG exposure to radiant heat (see Section H.3.5).

H.7.7 CONDENSATION

Ensure that there is no condensation that occurs on either sensor face prior to or during the calibration procedure (see Section H.6).

H.7.8 ELECTRICAL

Connect the signal wires of each HFG to the data-acquisition system, ensuring that the polarity of each HFG is set correctly with an increase in heat flux corresponding to an increase in millivolt signal.

H.8. CALIBRATION PROCEDURE

STEP 1

Measure the zero flux voltage and resistance of the HFGs.

STEP 2

Apply radiant heat to both sensors until the Standardized HFG reading reaches 5 W/cm^2 (4.4 BTU/ft^2*sec). A gradual heat radiance increase from 0 to 5 W/cm^2 (0 to 4.4 BTU/ft^2*sec) must occur within 45 ± 5 seconds.

STEP 3

Immediately begin decreasing the radiant heat. A gradual cool-down rate from 5 W/cm^2 (4.4 BTU/ft^2*sec) to less than 1 W/cm^2 (0.88 BTU/ft^2*sec) must occur over a minimum time period of 90 seconds.

STEP 4

At the upper threshold of 4 W/cm^2 (3.52 BTU/ft^2*sec), begin recording signal data continuously for both HFGs (See Section H.4).

STEP 5

At the lower threshold of 1 W/cm^2 (0.88 BTU/ft^2*sec), stop recording signal data.

STEP 6

Repeat STEP 1, verifying the HFGs return to previous conditions and document results.

H.9. ANALYSIS

Multiply the Standardized HFG millivolt values by the known slope and calculate the heat-flux level for each data point. A least squares fit procedure is performed using the calculated heat flux and the Working HFG millivolt values. The linearized slope is determined by:

$$\Delta Y \text{ (Units)}/\Delta X \text{ (mV)}$$

Where:

Y = Standardized HFG (W/cm^2 or BTU's/ft^2*sec)

X = Working HFG (millivolts)

Note:

*To convert BTU's/ft^2*sec to W/cm^2, multiply slope by 1.135654.*

*To convert W/cm^2 to BTU's/ft^2*sec, multiply slope by 0.88.*

H.10. REQUIREMENTS

H.10.1 REPRODUCIBILITY

It must be shown that if the locations of the two HFGs are interchanged and the calibration is repeated, the difference in the successive calibration factor must not be greater than + 3%. If the calibration results are within range, use the average as the calibration factor.

H.11. REPORTING

Record the required parameters as shown in table H-1.

Table H-1. Required reporting parameters

<table>
<tr><th>TOPIC</th><th>SUBTOPIC</th><th colspan="2">DETAILS</th></tr>
<tr><td rowspan="4">General</td><td>Calibration facility</td><td colspan="2">Facility conducting calibration</td></tr>
<tr><td>Customer</td><td colspan="2">Lab performing future tests with the working HFG</td></tr>
<tr><td>Calibration date</td><td colspan="2">Year/Month/Day</td></tr>
<tr><td>Calibration expiration Date</td><td colspan="2">Year/Month/Day</td></tr>
<tr><td rowspan="16">Working HFG Information</td><td>Manufacturer</td><td colspan="2"></td></tr>
<tr><td>Part number</td><td colspan="2"></td></tr>
<tr><td>Serial number</td><td colspan="2"></td></tr>
<tr><td>Gauge type</td><td colspan="2">Gardon or Schmidt-Boelter</td></tr>
<tr><td rowspan="2">Coating</td><td colspan="2">Paint information</td></tr>
<tr><td colspan="2">Last date painted</td></tr>
<tr><td>Calibration factor</td><td colspan="2">BTU/ft^2*sec or W/cm^2</td></tr>
<tr><td rowspan="4">Voltage/Resistance (zero flux)</td><td rowspan="2">Pre-calibration</td><td>Voltage</td></tr>
<tr><td>Ohm</td></tr>
<tr><td rowspan="2">Post-Calibration</td><td>Voltage</td></tr>
<tr><td>Ohm</td></tr>
<tr><td rowspan="5">Prior calibration data (If available)</td><td colspan="2">Date</td></tr>
<tr><td>Calibration Factor</td><td>BTU/ft^2*sec/mV or $W/cm^2/mV$</td></tr>
<tr><td colspan="2">Facility where calibration was conducted</td></tr>
<tr><td colspan="2">Percent change in calibration factor</td></tr>
<tr><td colspan="2">Traceability records to a Standardized HFG</td></tr>
</table>

Table H-1. Required reporting parameters (continued)

<table>
<tr><th>TOPIC</th><th>SUBTOPIC</th><th colspan="2">DETAILS</th></tr>
<tr><td rowspan="14">Standardized HFG Information</td><td>Manufacturer</td><td colspan="2"></td></tr>
<tr><td>Part number</td><td colspan="2"></td></tr>
<tr><td>Serial number</td><td colspan="2"></td></tr>
<tr><td>Gauge type</td><td colspan="2">Gardon or Schmidt-Boelter</td></tr>
<tr><td rowspan="2">Gauge coating material and nominal thickness</td><td colspan="2">Paint information</td></tr>
<tr><td colspan="2">Nominal thickness (mils)</td></tr>
<tr><td>Calibration factor</td><td colspan="2">BTU/ft^2*sec/mV or W/cm^2/mV</td></tr>
<tr><td rowspan="4">Gauge voltage and ohm reading between signal leads at zero flux</td><td rowspan="2">Pre Calibration</td><td>Voltage</td></tr>
<tr><td>Ohm</td></tr>
<tr><td rowspan="2">Post Calibration</td><td>Voltage</td></tr>
<tr><td>Ohm</td></tr>
<tr><td>Calibration date of Standardized HFG</td><td colspan="2">Year/Month/Day</td></tr>
<tr><td>Traceability records to NIST Primary Standard HFG</td><td colspan="2"></td></tr>
<tr><td> </td><td colspan="2"></td></tr>
<tr><td rowspan="11">Results</td><td>HFG cooling water</td><td colspan="2">℉ or ℃</td></tr>
<tr><td>XY plot or raw data table</td><td colspan="2"></td></tr>
<tr><td>Flux type</td><td colspan="2">Incident</td></tr>
<tr><td>Gauge type</td><td colspan="2">Gardon or Schmidt-Boelter</td></tr>
<tr><td>Linearity of HFG mV signals during calibration</td><td colspan="2">Confidence level</td></tr>
<tr><td>Calibration traceability</td><td colspan="2"></td></tr>
<tr><td>Calibration certificates of devices used</td><td colspan="2"></td></tr>
<tr><td>Calibration factor (initial)</td><td colspan="2">BTU/ft^2*sec/mV or W/cm^2/mV</td></tr>
<tr><td>Calibration factor (reproducibility)</td><td colspan="2">BTU/ft^2*sec/mV or W/cm^2/mV</td></tr>
<tr><td>% Error (< 3)</td><td colspan="2">%</td></tr>
<tr><td>Calibration factor (average)</td><td colspan="2">BTU/ft^2*sec/mV or W/cm^2/mV</td></tr>
</table>

APPENDIX I—BUNSEN BURNER APPARATUS AND EQUIPMENT DETAILS

I.1. SCOPE

I.1.1 APPLICABILITY

This test apparatus is intended for use in determining the resistance of materials to a Bunsen burner flame.

I.2. DEFINITIONS

I.2.1 IGNITION TIME

Ignition time is the length of time the burner flame is applied to the sample.

I.2.2 FLAME TIME

Flame time is the time in seconds that the sample continues to flame after the burner flame is removed from beneath the sample.

I.2.3 DRIP FLAME TIME

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the sample to the floor of the chamber.

I.2.4 BURN LENGTH

Burn length is the distance from the original sample edge to the farthest evidence of damage to the test sample due to that area's combustion.

I.3. TEST APPARATUS

I.3.1 TEST CABINET

Tests must be conducted in a draft-free cabinet or other enclosure acceptable to the FAA. The test cabinet must have a viewing window set up such that both sides of the sample can be observed during testing. Using a mirror to observe the back of the sample is allowed. 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 at least 0.04-inch thick (1 mm) must be used for the bottom surface of the chamber or enclosure.

NOTE: Draft-free implies a condition of no air currents in a closed in space. However, to avoid suffocation of the flame, the cabinet should not be airtight. 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.

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

NOTE: Suitable test cabinets of the type described are manufactured by Marlin Engineering of Bellingham, WA; Deatak Testing Instruments of McHenry, IL; and Atlas Material Testing Solutions of Mount Prospect, IL.

I.3.3 BURNER

The burner must be a Bunsen or Tirrill type. The burner must have a 0.375-inch (10-mm) inside diameter barrel. A Tirrill burner is 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. If using a Bunsen burner, there must be a means to regulate the gas flow (e.g. a needle valve) to achieve the flame height, and all aspirating holes at the bottom of the burner must be closed. Either burner should have a 0.036+0.0002/-0.0003-inch orifice.

The burner base is marked for natural gas. There must be a means provided to move the burner into and out of test position when the cabinet door is closed. An example Bunsen burner is shown in figure I-1.

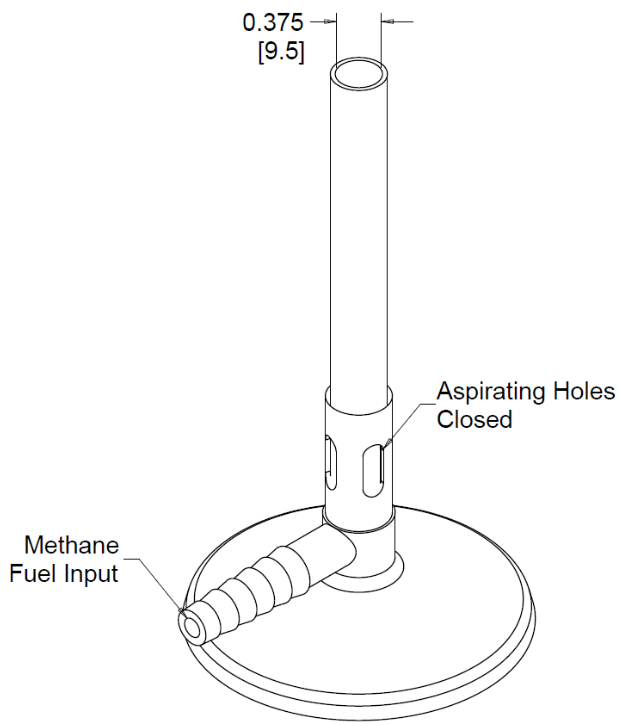


Figure I-1. A Bunsen burner example with aspirating holes closed

NOTE: Natural gas is marked on the base of the burner. This is because natural gas is composed of more than 90 percent methane, and there is no orifice size specific to methane. Humboldt Company is one manufacturer of the Bunsen and Tirrill burners. They are located in Schiller Park, Illinois and their phone number is (800) 544-7220. Other manufacturers and distributors of the burners may be found on the Internet.

I.3.3.1 Burner Fuel

A diffusion flame using methane gas of 99 percent certified purity (CP) must be used (i.e., without adding air through the aspirating holes at the bottom of the burner barrel).

I.3.3.2 Plumbing for Gas Supply

A control-valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2.5 ± 0.25 psi (17 ± 2 kPa) at the burner inlet must be installed between the gas supply and the burner. If using a Bunsen burner, a needle valve needs to be placed between the fuel-pressure regulator and burner inlet to control the flame height.

NOTE: 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.

I.3.3.3 Flame-Height Indicator

A flame-height indicator may be used to aid in setting the height of the flame. The flame height is set to 1.5 inches (38 mm) for all Bunsen burner tests, except the 60-degree wire test in which the flame height is set to 3 inches (76 mm). It is suggested to fabricate a flame height indicator similar to the one shown in figure I-2. When 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 the proper flame profile is achieved when the tip of the flame is 1.5 inches (38 mm) long and the height of the inner cone is 0.875 inch (22 mm). When the tip of the flame is 3 inches (76 mm) long, the height of the inner cone is 1 inch (25 mm). 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. However, the inner cone of the flame is more visible and easily seen.

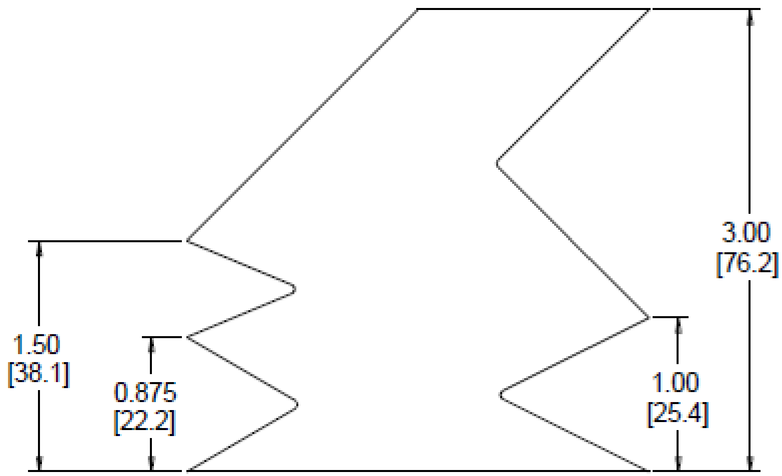


Figure I-2. An example flame-height indicator

I.4. INSTRUMENTATION

I.4.1 TIMING DEVICE

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame (ignition time), the flame time, and the drip flame time.

I.4.2 RULER

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

APPENDIX J—APPARATUS FOR EVACUATION SLIDE RADIANT HEAT TEST

J.1. SCOPE

J.1.1 APPLICABILITY

This test apparatus is intended for use in determining the ability of a material to resist heat and maintain pressure when subjected to a radiant heat source that simulates a large jet fuel fire.

J.2. DEFINITIONS

J.2.1 RADIANT HEAT SOURCE

The radiant heat source is a 3-inch diameter circular electric furnace with a spiral tubular heating element.

J.2.2 TIME TO FAILURE

The time to failure is the time between first application of heat to the sample and the first decrease in pressure below the maximum pressure attained in the test cylinder during the test.

J.2.3 TEST SAMPLE

A test sample is a flat, 7-inch diameter circle that must replicate a material installed on an aircraft.

J.3. TEST APPARATUS

J.3.1 PRESSURE CYLINDER SAMPLE HOLDER

The pressure cylinder consists of a 12.375-inch-long (314 mm) aluminum cylinder with a 7-inch (178 mm) outside diameter (OD) and a 6.5-inch (165 mm) inside diameter (ID), as shown in figures J-1 and J-2.

J.3.1.1 An aluminum plate 0.5-inch (13 mm) thick must be welded to one end of the cylinder and must be drilled and tapped near its upper edge for a 0.25-inch (6.4-mm) National Pipe Thread (NPT) pipe to facilitate the installation of air pressure and pressure recording equipment.

J.3.1.2 An aluminum ring 7 inches (178 mm) OD, 5.5 inches (140 mm) ID, and 0.5 inch (13 mm) thick must be welded to the other end of the cylinder. The ring must have eight evenly spaced 10-32 bolt holes on the circle, 0.3125 inch (8 mm) from the ring's inner edge. The diameter of this circle is 6.125 inches (156 mm), and the adjacent bolt holes are 2.3125 inches (59 mm) apart (see figure J-2 for detail dimensions). A 10-32 steel bolt 0.875 inch (22 mm) long will be placed into each of the holes.

J.3.1.3 Another aluminum ring, 6.75 inches (171 mm) OD, 5.5 inches (140 mm) ID, and 0.5 inch (13 mm) thick, with two neoprene or comparable (e.g., silicone rubber) gaskets with similar clearance holes to fit over the bolts, must provide a means for clamping and sealing the test sample in place. Hinges and adjustable stops will be welded to the sides of the cylinder, as shown in figures J-1 and J-2.

NOTE: It is acceptable to use toggle clamps instead of nuts and bolts (see figure J-1) as a method to secure the test sample in place between the aluminum ring holder and the pressure cylinder.

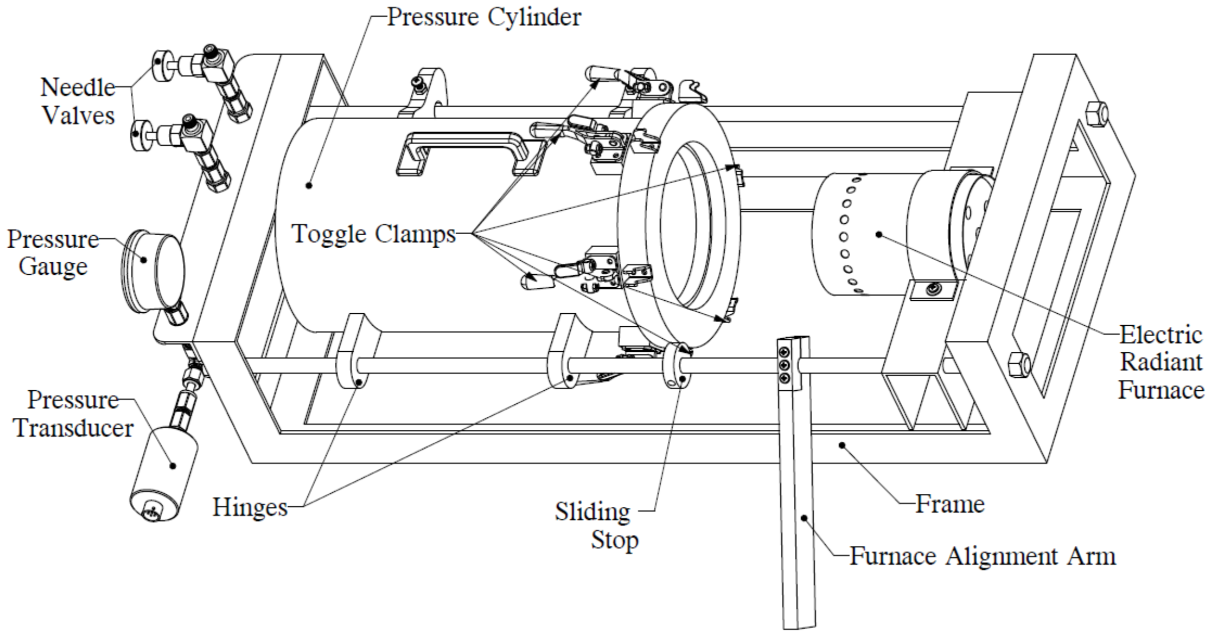


Figure J-1. Overview of evacuation slide material test apparatus

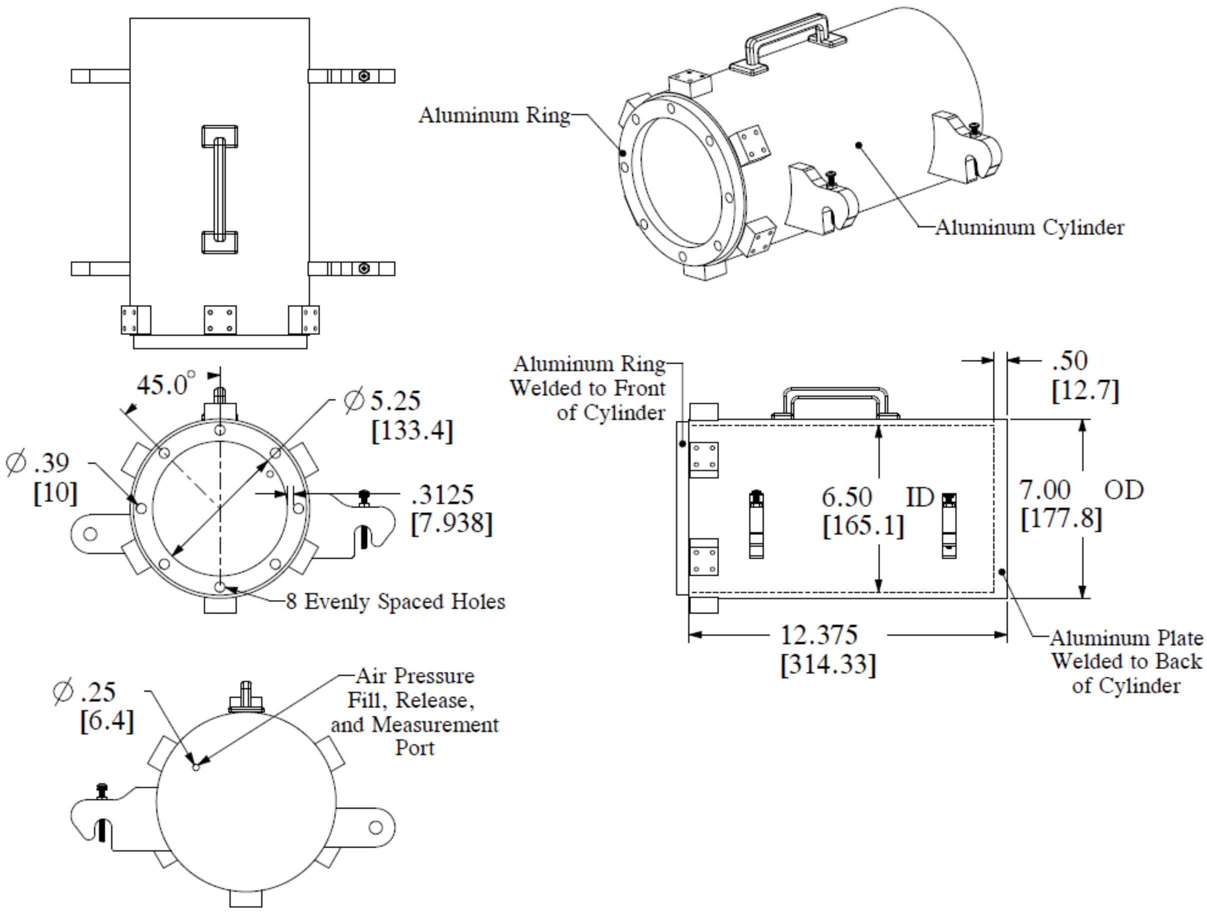


Figure J-2. Dimensioned drawing of the pressure cylinder

J.3.2 TEST-APPARATUS FRAME

The test-apparatus frame must be able to support the electric furnace and pressure cylinder sample holder. The furnace is fixed in place at one end, whereas the pressure cylinder must be able to rotate into and out of test position and also translate toward and away from the furnace. The dimensions of the frame are not critical, but an example is shown in figure J-3.

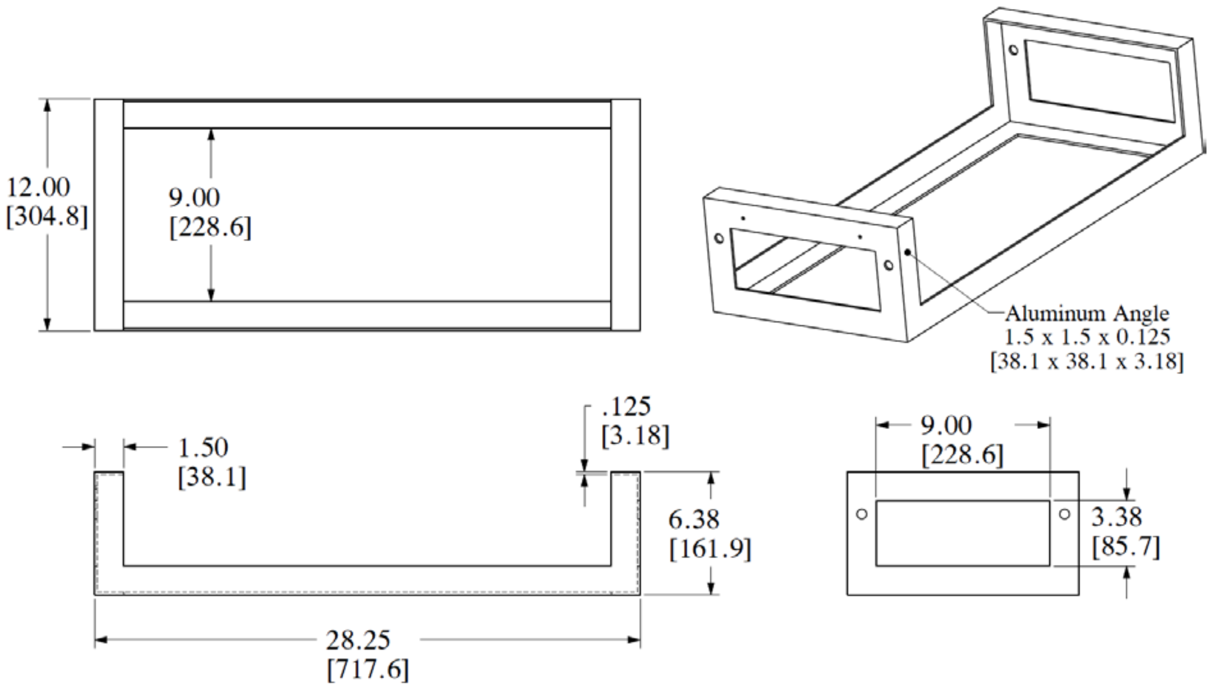


Figure J-3. Dimensioned drawing of the frame

J.3.3 ELECTRIC FURNACE

An electric radiant furnace with a 3-inch (76-mm) diameter opening, as shown in figure J-4, must be used to supply a constant irradiance on the sample surface. The radiant furnace uses a spiral tubular heating element with a 0.260-inch Inconel sheath diameter as the heat source. The diameter of the spiral element is nominally 3 inches. It is an 875-watt, 120-volt alternating current (AC) element with an internal resistance of approximately 17 ohms. The front half of the furnace housing is constructed from rolled sheet metal with an outer diameter (OD) of 4 inches (102 mm) and inside diameter (ID) of 3.938 inches (100 mm). The back half has an OD of 3.875 inches (98 mm) and an ID of 3.813 inches (97 mm). The face of the furnace coil is recessed 0.0938 inch (2.4 mm) from the edge of the front housing. Ceramic insulating rings are placed inside the housing to fill the space between the heating coil and the housing.

NOTE: A suitable 875-watt electric furnace is manufactured by Newport Scientific Inc. of Jessup, MD, 301-498-6700. Part numbers 68086038000 and 68086040400 are both acceptable. This is the same furnace used in the NBS Smoke Density Chamber

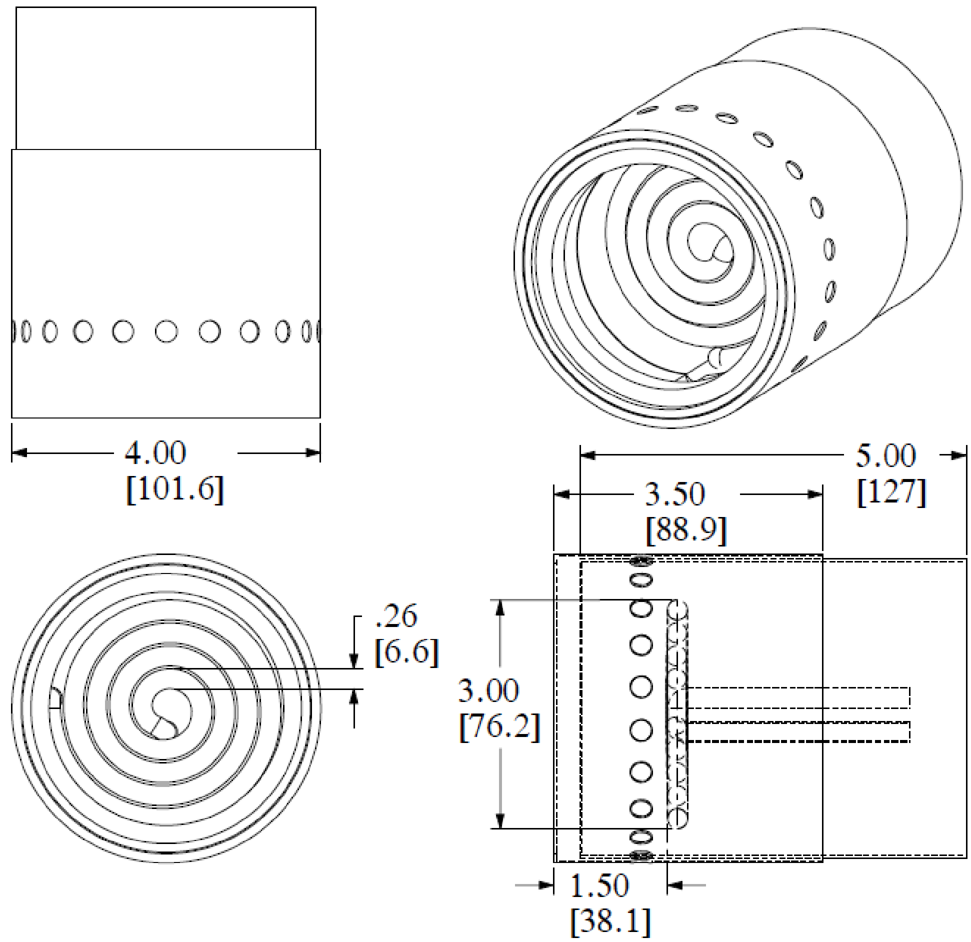


Figure J-4. Dimensioned drawing of the electric radiant furnace

J.3.3.1 Heating-Element Orientation

The heating element must be oriented as shown in figure J-5. This orientation will minimize interlab differences because results have shown that orientation influences the shape of the heat profile impacting the test sample.

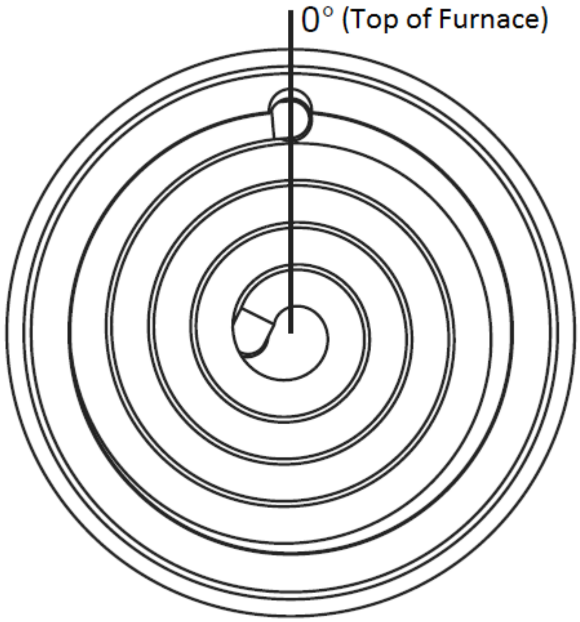


Figure J-5. Heating element orientation

J.3.3.2 Heating Element Position

The location of the heat element must be 1.5 inches from the open face of the furnace for part number 68086038000 or 1.75 inches for part number 68086040400.

J.3.4 FURNACE POWER CONTROL

A variable voltage or power control unit—115-volt, 600-watt minimum—will be connected to the electric furnace power supply to adequately control the heat flux from the furnace. The furnace control system will be capable of maintaining the irradiance level under steady-state conditions for a minimum of 20 minutes.

NOTE: A suitable power control unit is manufactured by Keysight Technologies of Santa Rosa, CA. Model AC6802 Basic AC Power Source rated at 1000 VA is acceptable.

J.3.5 VOLTMETER

The voltmeter is used to measure the input AC voltage going to the furnace, and must have a range capable of measuring the maximum AC voltage produced by the input circuitry (typically 0–120 volts or 0–240 volts).

J.3.6 AMMETER

The ammeter is used to measure the input AC current going to the furnace, and must have a minimum range of 0–7.5 amperes.

J.3.7 APPARATUS FRAMEWORK

J.3.7.1 Pressure Supply and Equipment

Compressed air is supplied to the pressure cylinder through a needle valve attached to the end of the framework. A tee-manifold on the outlet side of the valve provides for a 0 to 5 psig pressure gauge, a transducer, a flexible tube for supplying air to the rear plate of the pressure cylinder, and a bleed valve, as shown in figure J-6.

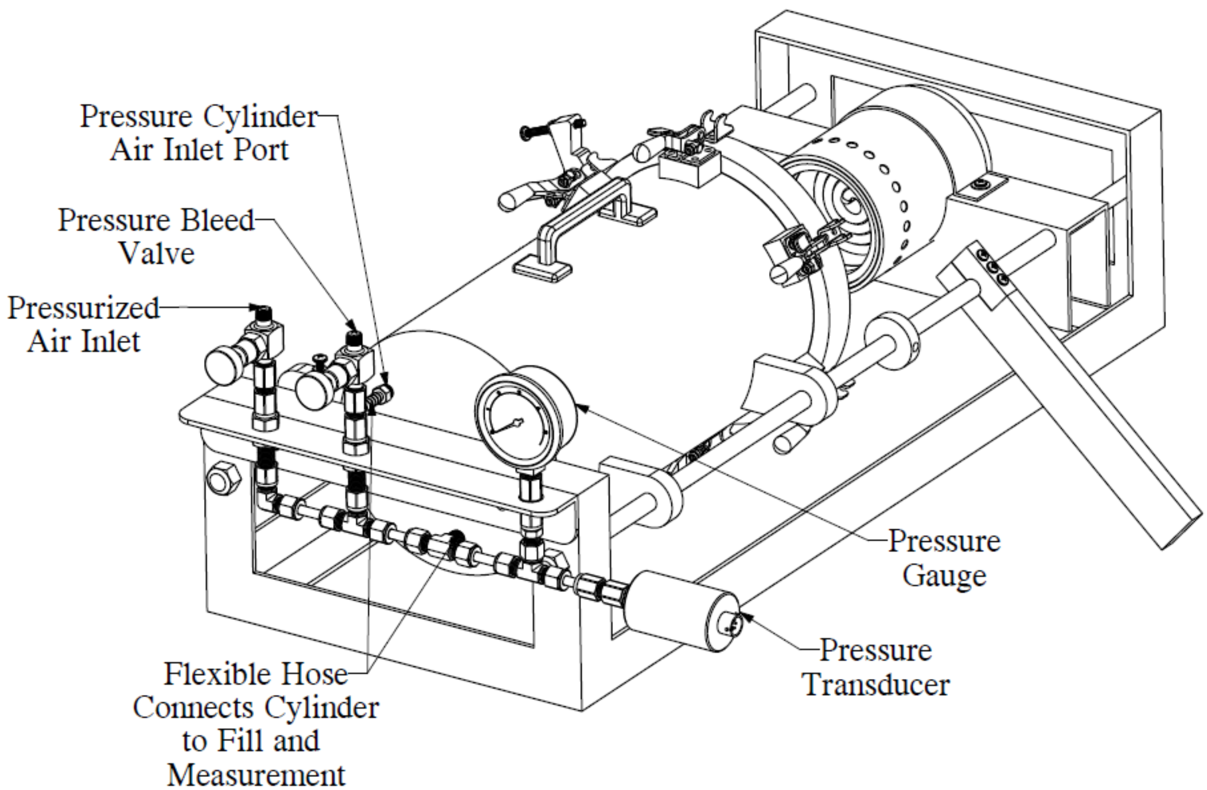


Figure J-6. Evacuation slide test apparatus in test position

J.3.8 ALIGNMENT TOOLS

J.3.8.1. Pressure Cylinder Alignment Tool

It is recommended that a tool be used to align the center of the furnace with the pressure cylinder. The tool must be a round disk with a 4-inch hole in the center, designed to either be bolted to the pressure cylinder or fit with the toggle clamps. An example of a tool that can be bolted is a 6.75-inch diameter disk with 8 evenly spaced holes placed 3.0625 inches from the center (see figure J-7). An example of a tool to fit a pressure cylinder with clamps has a 5.5-inch diameter lip to fit within the inside diameter of the pressure cylinder (see figure J-8).

No matter which design is used, it must be mounted on the front of the pressure cylinder and slid in front of the furnace. Then adjustments must be made to align the 4-inch inner diameter of the tool with the 4-inch outer diameter of the furnace (see figure J-9).

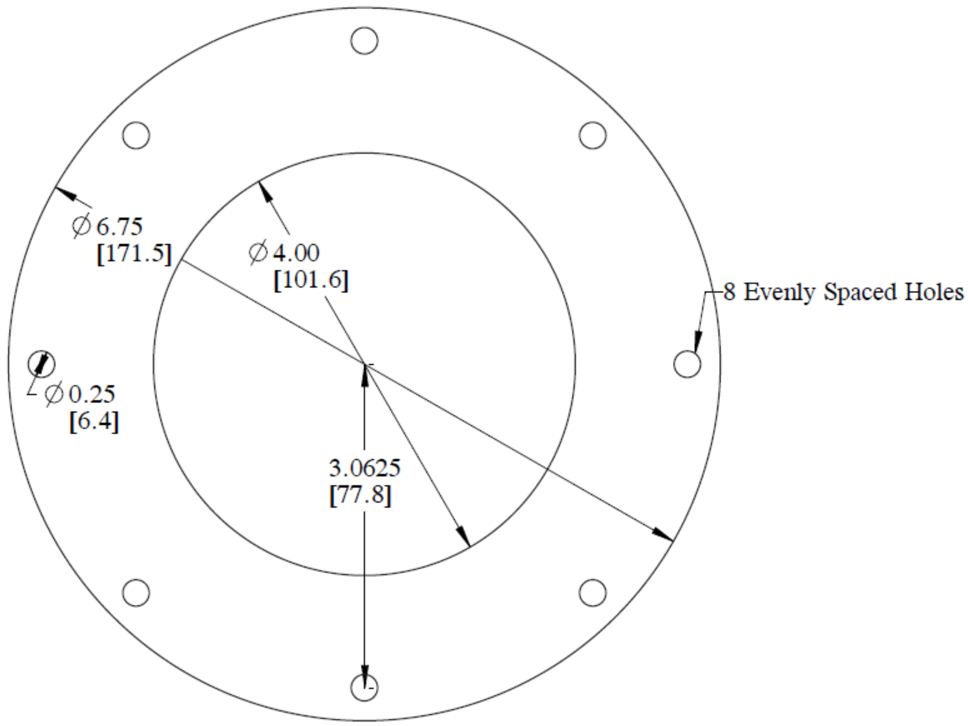


Figure J-7. Pressure-cylinder alignment tool for bolted design

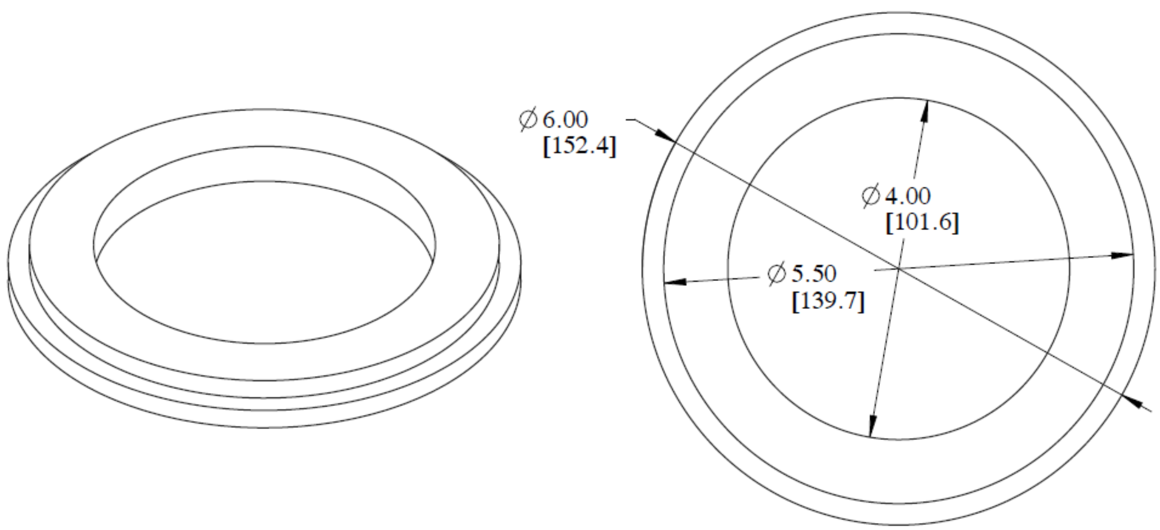


Figure J-8. Pressure-cylinder alignment tool for toggle clamps

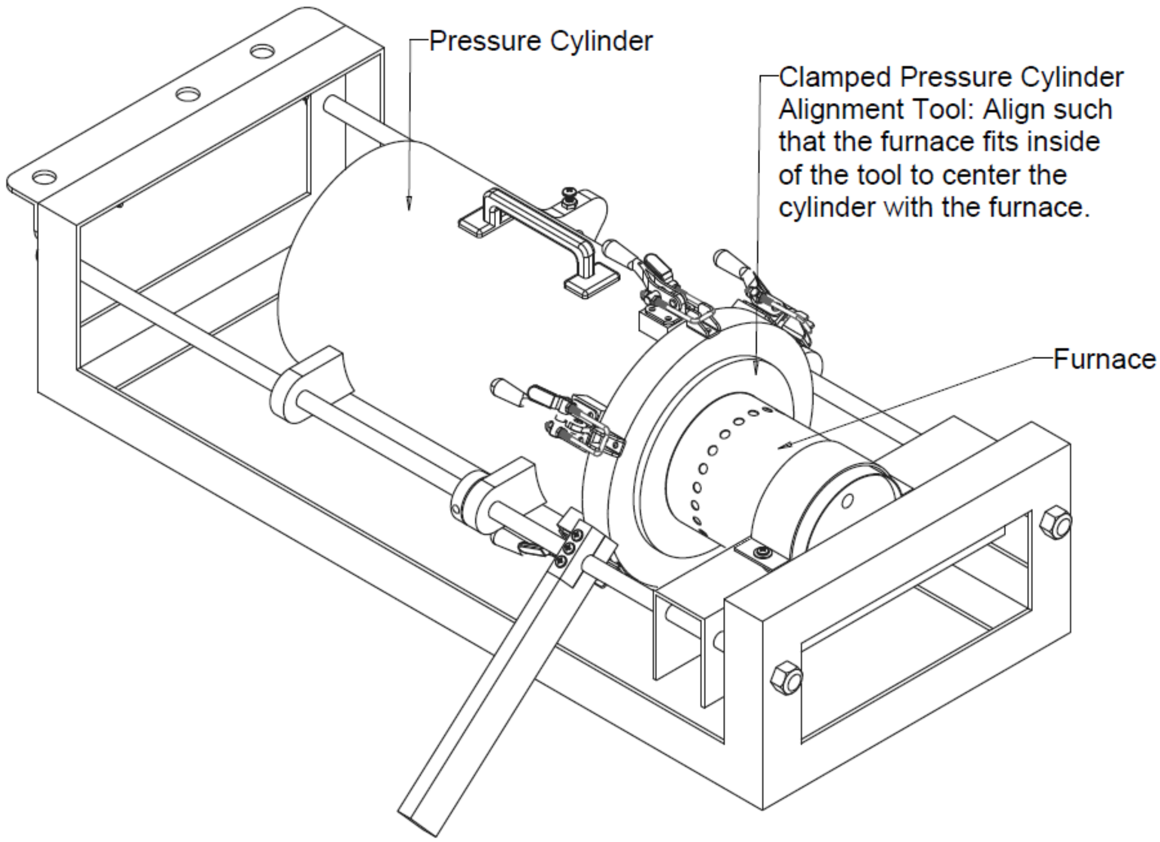


Figure J-9. Clamped cylinder-alignment tool in place

J.3.8.2 Test Sample-to-Furnace Distance-Measurement Tool

After pressurizing the pressure cylinder with a test sample in place, the surface of the sample expands outward. The farthest edge of this surface must be placed 2 inches from the front of the furnace. This must be measured when the pressure cylinder is away from the furnace to not expose the sample to its radiant heat. Therefore, a metal plate that aligns with the front of the furnace is to be placed in front of the pressure cylinder when it is rotated out of position (see figure J-10). To reach the correct position, slide the pressure cylinder until the expanded surface of the test sample is 2 inches from the metal plate and tighten the sliding stop to hold that position.

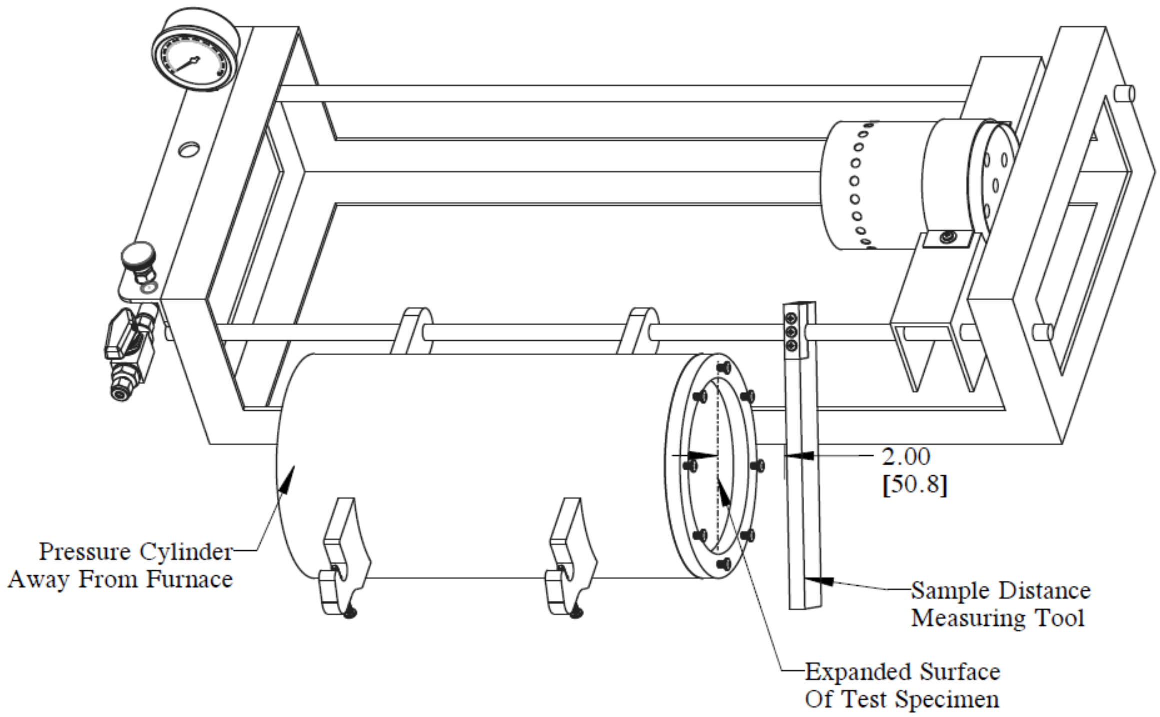


Figure J-10. Sample-to-furnace distance measurement

J.3.9 INSTRUMENTATION

J.3.9.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the power input of the furnace and pressure transducer. If a voltmeter is used, it requires a resolution of 0.01 mV and an accuracy of 0.3 percent.

J.3.9.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame and the test-sample ignition and extinguishment times.

APPENDIX K—SONIC FIRE TEST BURNER APPARATUS

K.1. SCOPE

K.1.1 APPLICABILITY

This chapter describes in detail the FAA Sonic Fire Test Burner, also known as the "Next Generation" or the "NexGen" burner.

K.2. DESCRIPTION

K.2.1 SONIC BURNER

This section describes in detail the FAA Sonic Fire Test Burner, also known as the "Next Generation" or the "NexGen" burner. The Sonic burner is specified in multiple FAA fire-test methods, although certain burner adjustments differ according to each specific test method.

The burner is a gun-type, using a pressurized, sprayed fuel charge in conjunction with a ducted air source to produce the burner flames. An interchangeable, screw-in fuel nozzle will be used to produce the conically shaped fuel charge from a pressurized fuel source. A pressurized air source controlled via a regulated sonic nozzle will supply the combustion air. The combustion air will be ducted through a cylindrical draft tube containing a series of diffusing vanes. There are several types of internal vanes used to diffuse the combustion air. The diffused combustion air will mix with the sprayed fuel charge in a bell-shaped combustion cone. The fuel/air charge will be ignited by a high-voltage spark plug positioned in the burner cone. Flame characteristics can be adjusted by varying the pressure of the regulated air into the sonic nozzle and proper positioning of the fuel spray nozzle. A schematic of the Sonic fire test burner is displayed in figure K-1. Note that the configuration of the burner components will be test-method specific and described in the respective chapter.

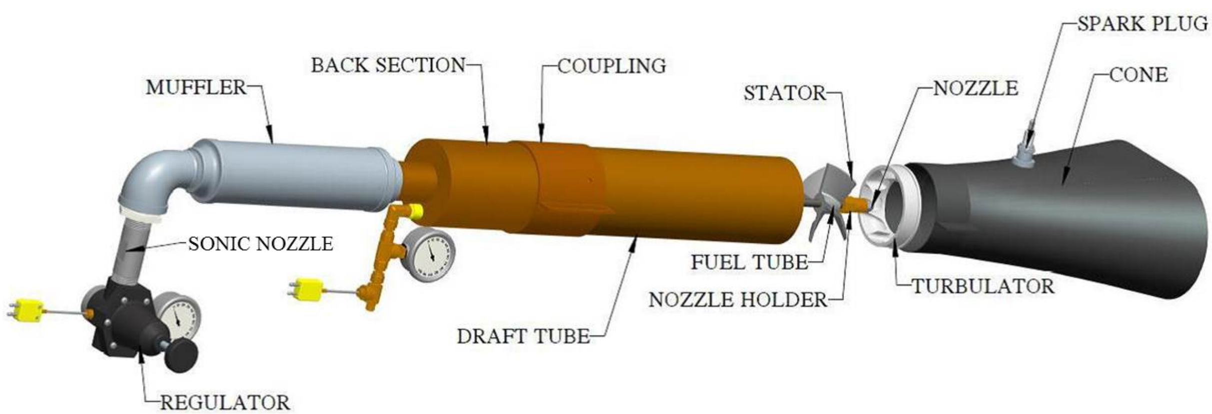


Figure K-1. Schematic of the sonic burner—Exploded view

K.3. TEST APPARATUS COMPONENTS

K.3.1 BURNER HOUSING

The burner housing is comprised of three main sections: the draft tube, the coupling, and the back section. The draft tube is constructed of 4-inch inner diameter steel tubing with a wall thickness of 0.125-inch (3.2-mm). The length of the draft tube is 15 inches (381 mm), with 3 inches (76.2 mm) of the tube inserted into the coupling, resulting in a coupling-to-tip distance of 12 inches (304.8 mm) inches (see figure K-2). The coupling is constructed of 4.25-inch (108-mm) inner diameter steel tubing that is 4 inches (102 mm) long with an outer diameter of 4.75 inches (120.7 mm). Three set-screw holes are 120 degrees apart and are drilled 1 inch (25.4 mm) in from the edge to hold the draft tube in place. The coupling has two mounting brackets welded to the sides for easy mounting and adjustment (see figure K-3). The back section is made of the same 4-inch (101.6-mm) tubing as the draft tube, but is 6 inches (152.4 mm) long, with 1 inch (25.4 mm) inserted into the coupling and welded in place (see figure K-4). A back plate is constructed of a 0.25-inch (6.4-mm) steel plate cut into a 4.25-inch (108-mm) diameter circle to cap the back section, with holes for the air inlet and fuel inlet (see figure K-5). A 1.5-inch National Pipe Thread (NPT) pipe nipple is cut to a length of 2.90 inches (73.7 mm) and welded into the 1.90-inch (48.3-mm) diameter recess cut to a depth of 0.145 inch (3.68 mm) on the center of the back plate (see figure K-6).

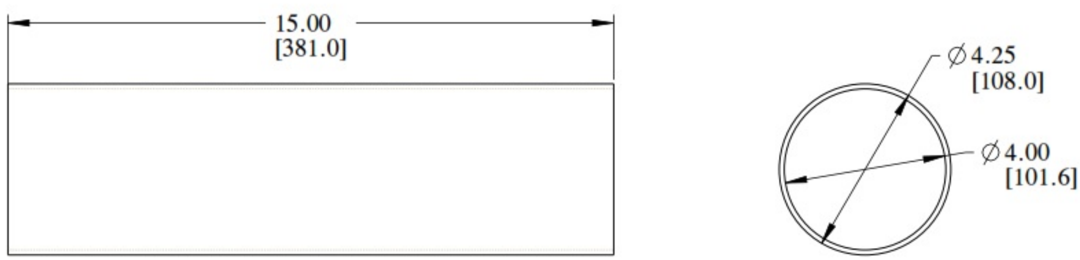


Figure K-2. Dimensioned drawing of the draft tube

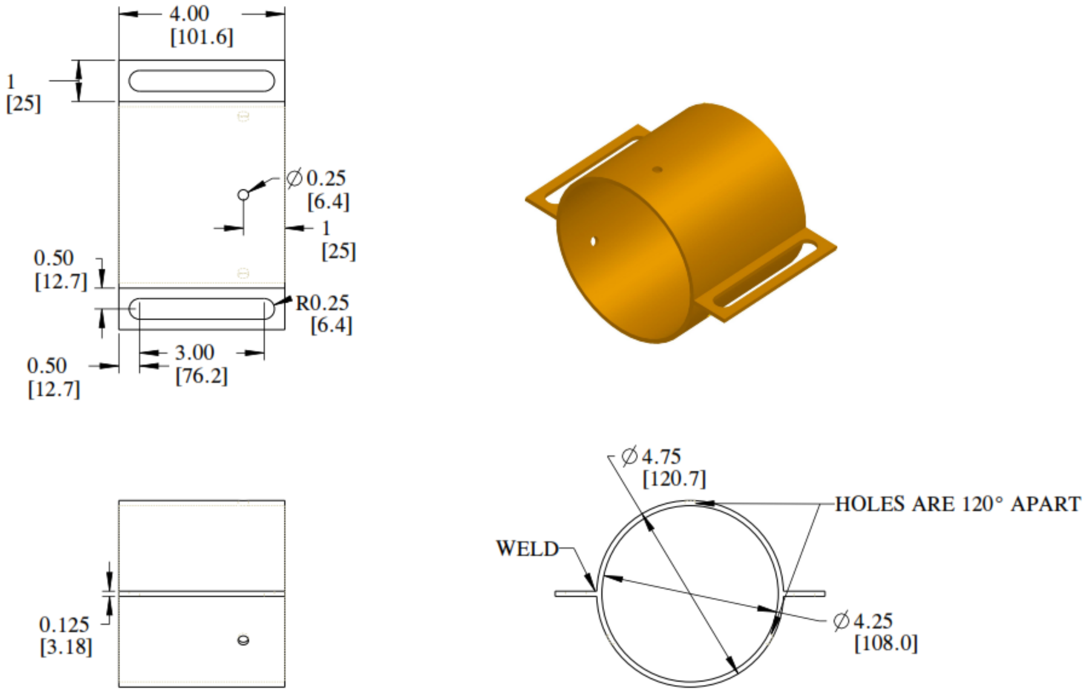


Figure K-3. Dimensioned drawing of the coupling

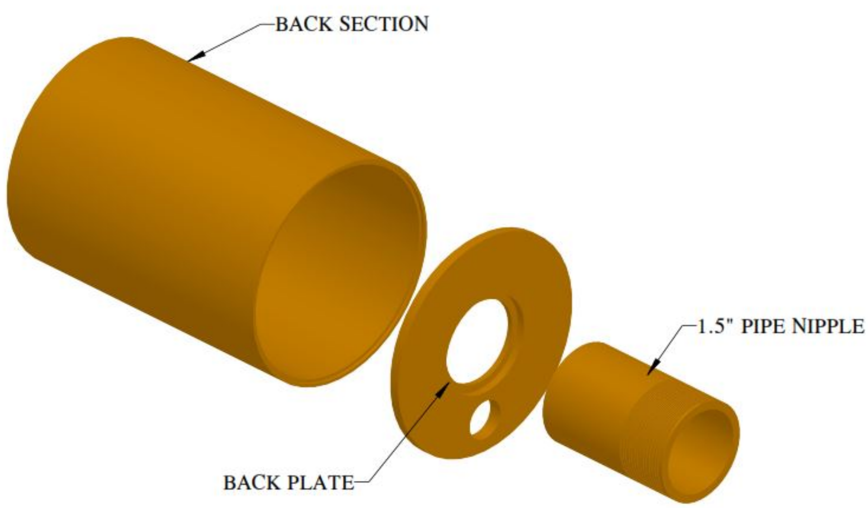


Figure K-4. Back section components—Exploded view

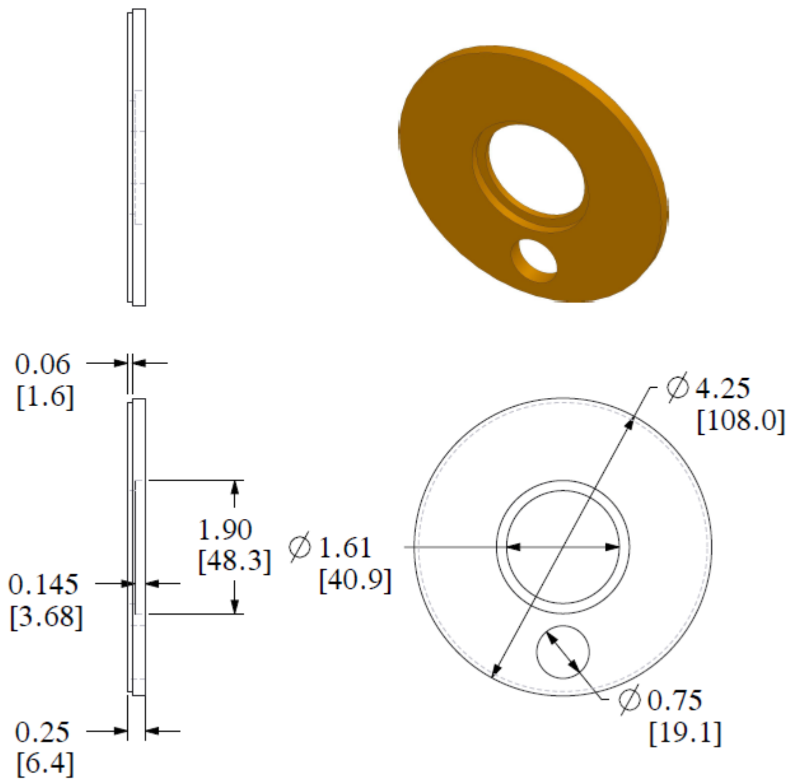


Figure K-5. Dimensioned drawing of the back plate

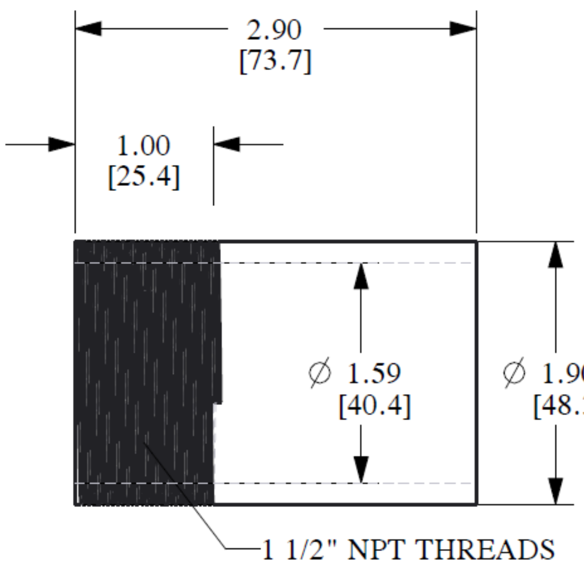


Figure K-6. Dimensioned drawing of the pipe nipple

K.3.2 COMBUSTION AIRFLOW CONTROL

K.3.2.1 Sonic Nozzle

The Sonic burner airflow is regulated with a sonic nozzle, which will deliver a constant mass-flow rate depending on the supplied inlet air pressure (see figure K-7). The nozzle is constructed from stainless steel with 1-inch NPT male thread ends. The throat diameter must be 0.25 inch (6.3 mm), which will deliver a mass flow rate, in standard cubic feet per minute (SCFM), as a function of inlet pressure, in pounds per square inch gauge, at a rate of:

$$\dot{m} = 0.89 * P_i + 12.43 \tag{K-1}$$

The exact inlet air pressure, and hence mass-flow rate, will be test-method specific and is described in the respective chapter. The nozzle that the FAA has used to develop the Sonic burner is manufactured by Fox Venturi Products of Dover, New Jersey, and is identified by part number 612021-8.

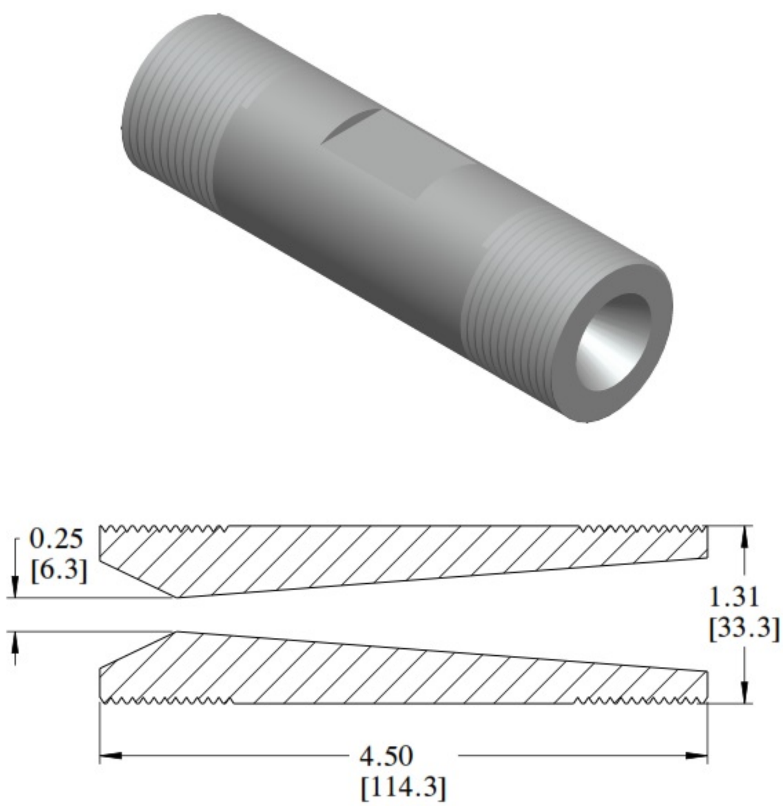


Figure K-7. Schematic of the sonic nozzle with cutaway view showing converging and diverging interior sections

K.3.2.2 Air-Pressure Regulator

The air pressure regulator is critical to maintaining the stability of the airflow supplied to the burner. The regulator should have 1-inch NPT female connections and at least one pressure tap for measurement of outlet pressure, and should regulate over the range at which the burner is normally operated (see figure K-8). The regulator must also maintain the desired pressure for the duration of a test. A suitable regulator is available from Grainger, item number 4ZM10 (manufactured by Speedaire) with an adjustment range of 5-125 lb/in^2 (0.034-0.862 MPa). Another suitable regulator is available from MSC Industrial, part number 73535627, manufactured by Parker (model R119-08CG/M2), with an adjustment range of 2-125 lb/in^2 (0.014-0.862 MPa).

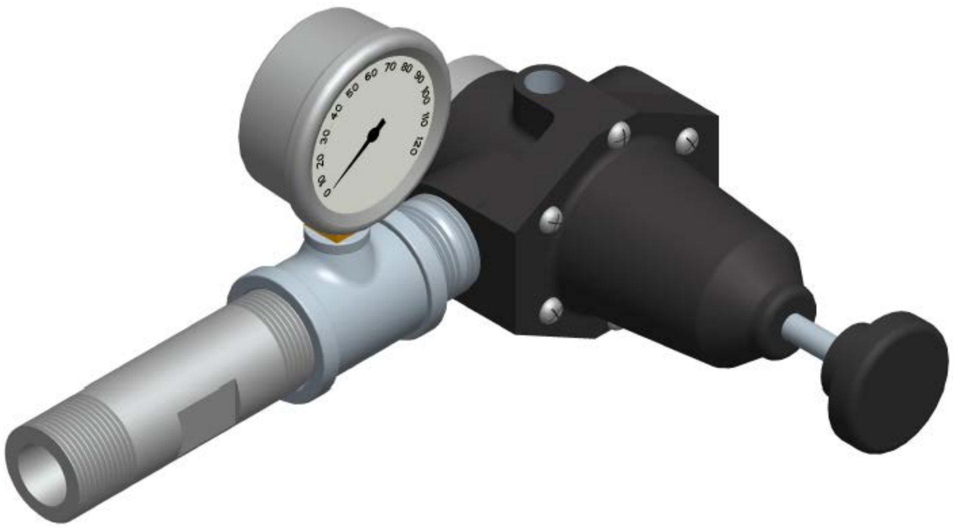


Figure K-8. Schematic of air-pressure regulator with sonic nozzle attached

K.3.2.3 Air-Pressure-Measurement Device

Correct air pressure at the inlet of the sonic nozzle is critical for establishing the proper mass flow of air through the sonic nozzle. The pressure-measuring device should be located nearest the point at which airflow enters the sonic nozzle. The pressure-measuring device may be connected to the port on the pressure regulator when using either of the specified models from section K.3.2.2. Otherwise, a 1-inch NPT tee fitting connected directly to the inlet side of the sonic nozzle is a suitable point of air-pressure measurement should the regulator be located upstream from the sonic nozzle or if an unspecified air pressure regulator is used (see figure K-8). The burner flame is highly sensitive to any fluctuations in the mass flow of air through the sonic nozzle. The pressure gauge or transducer must have NIST (or equivalent) traceable certification with a ± 2% accuracy or less. Digital gauges capable of reading in increments of 1 lb/in^2 (0.007 MPa) or less are recommended if a pressure transducer is not used. Should an analog gauge be used, it should be glycerin filled to reduce needle flutter and should have a dial that is easily read. The gauge or transducer must also have a working range appropriately suited for the range of air pressures typically used during tests. A suitable pressure transducer is supplied by Omega Engineering, part number PX329-100G5V. A suitable digital gauge is supplied by Omega Engineering, part number DPG1001B-100G.

K.3.2.4 Muffler

An airflow muffler is used to reduce the high-frequency noise created by the air expanding from the sonic nozzle throat. The 2.625-inch (66.7-mm) OD muffler has 1.5-inch NPT female thread connections, an overall length of 12 inches (305 mm), and has no internal baffles or tubes. A suitable muffler is supplied by McMaster-Carr, part number 5889K73 (see figure K-9). Low-pressure drop polyurethane foam must be used to further reduce the noise issuing from the burner. The foam can be cut into a cylinder 3 inches (76.2 mm) in diameter by 12 inches (305 mm) long and should have a density of approximately 1.20-1.50 lb/ft^3 (19.2–24.0 kg/m^3) with a porosity of approximately 20 ± 2 pores/inch (787 ± 79 pores/m). It is necessary to affix two pieces of safety wire to the muffler's internal steel mesh at the outlet end to prevent the foam cylinder from moving out of position and into the burner housing. The two wires should be arranged perpendicular to each other in a cross pattern and have a wire diameter of 0.032 inch (0.8 mm) or less (see figure K-10). The male outlet of the sonic nozzle connects to a 1-inch NPT female to 1.5-inch male hex reducing bushing. The hex-bushing male outlet connects to the intake side of the muffler via a 1.5-inch NPT female to 1.5-inch NPT male, 90-degree, Schedule 40 standard wall steel street elbow.

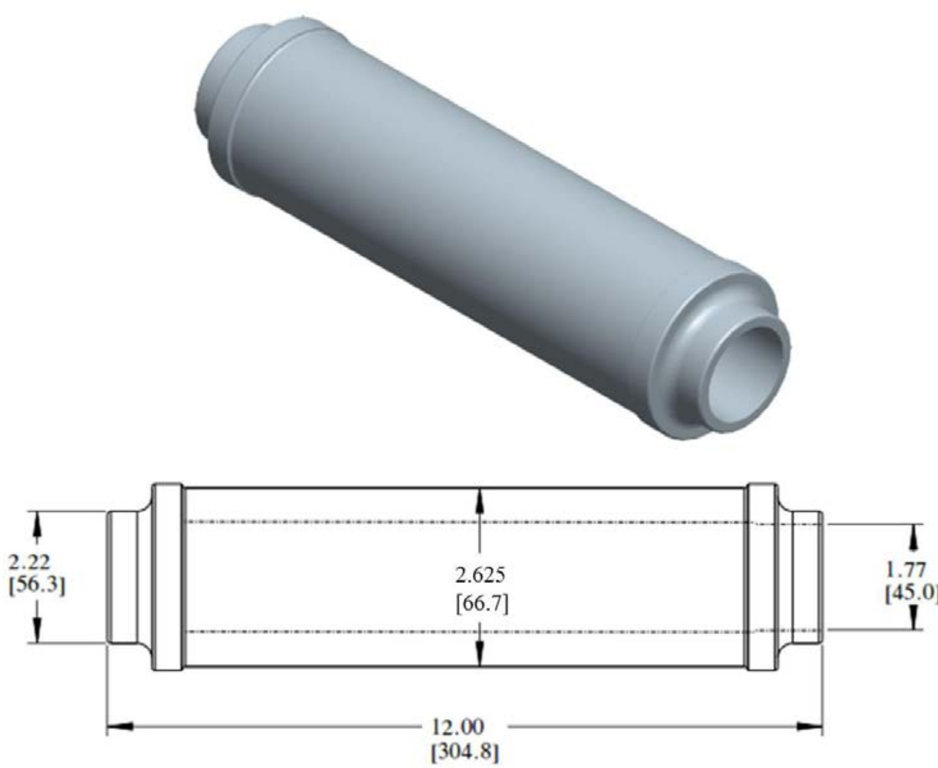


Figure K-9. Schematic of the muffler

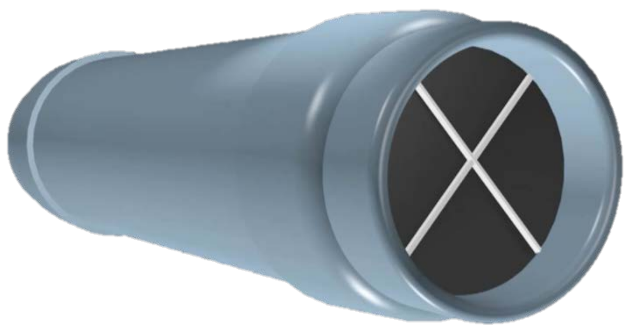


Figure K-10. Safety wire affixed to inside of the muffler for restraining foam insert

K.3.2.5 Air Temperature

The air temperature must be maintained at 50° ± 10°F (10° ± 6°C) for the duration of a test. This can be achieved by constructing a heat-exchange system, as described later in this appendix.

K.3.3 AIR DIFFUSION USING STATOR AND TURBULATOR

The stator and turbulator are used to deflect and diffuse the airflow within the Sonic burner. Three-dimensional drawing files can be used to fabricate the components on a Computer Numerical Control (CNC) milling machine. These files can be downloaded from the FAA's Fire Safety website: http://www.fire.tc.faa.gov/materials/burnthru/nexgen.stm.

K.3.3.1 Stator

The stator is a four-vane internal component that creates a swirling flow aligning the fuel tube with the center axis of the draft tube. The stator is 4 inches (102 mm) in diameter and should have a snug fit when placed inside the draft tube (see figure K-11). A suitable stator is supplied by Marlin Engineering, part number ME1513-3.

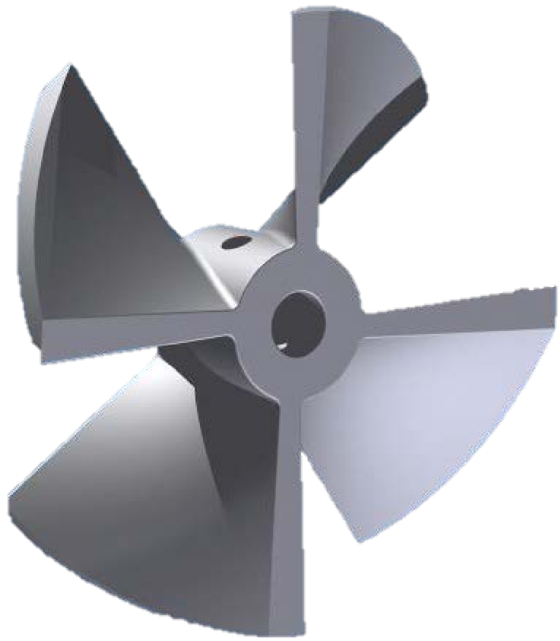


Figure K-11. Stator

K.3.3.2 Turbulator

The turbulator is a 4-inch (102-mm) diameter component, for air swirling, placed in the end of the draft tube. The center hole is 2.75 inches (69.9 mm) in diameter (see figure K-12). A suitable turbulator is supplied by Marlin Engineering, part number ME1512-1.

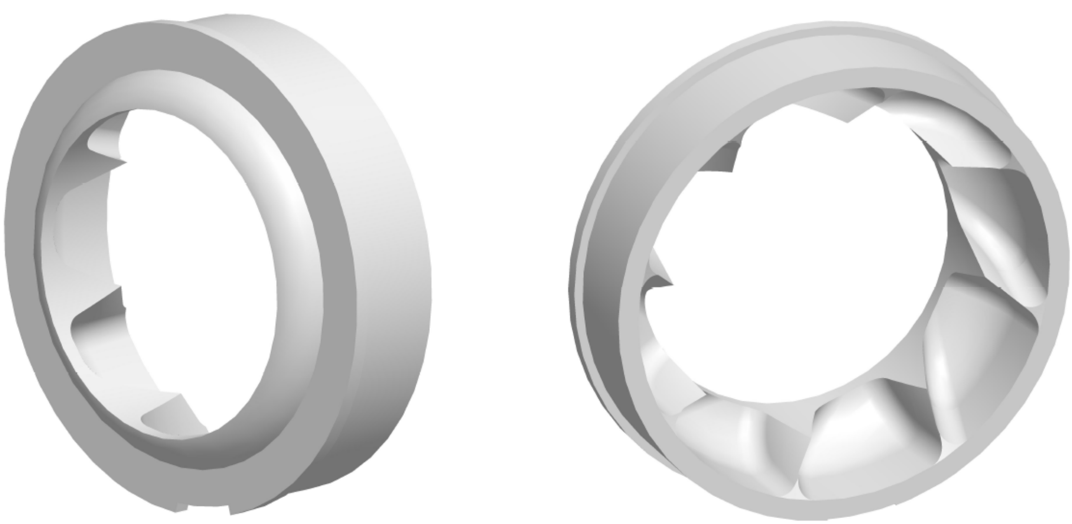


Figure K-12. Turbulator: front and back view

K.3.3.3 Stator and Turbulator Configuration

The stator slides onto the fuel tube, is oriented in the proper direction, and is locked into place with a set screw located at the twelve o'clock position (see figure K-13). The turbulator is placed on the end of the draft tube with the notch located at the six o'clock position (see figure K-14). The typical configuration positions the face of the stator approximately 2.6875 inches (68.263 mm) from the exit plane of the turbulator (see figure K-15). Refer to the Preparation of Apparatus section for the exact positioning of the stator and turbulator.

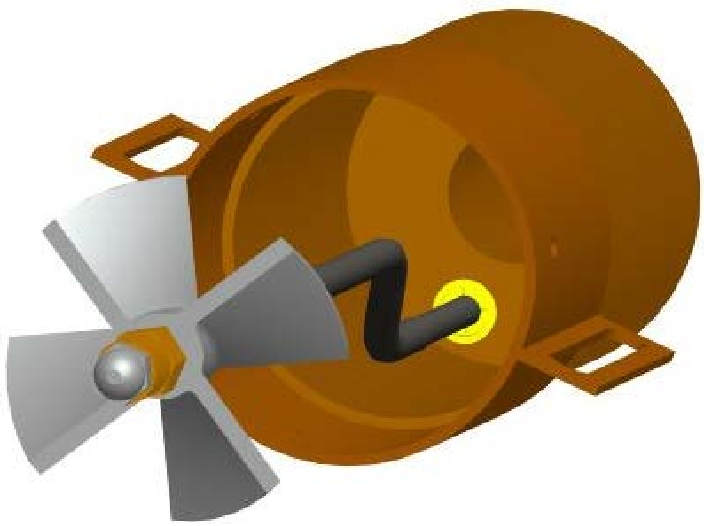


Figure K-13. Location of the stator on the fuel tube

Figure K-14. Position of turbulator at the end of the draft tube

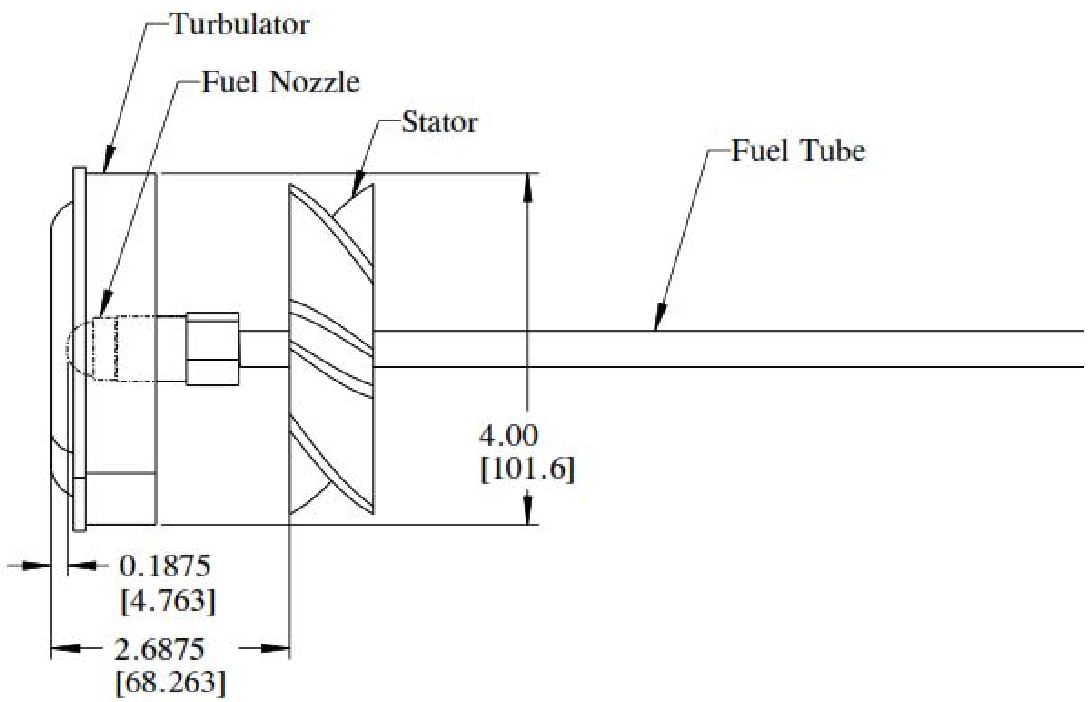


Figure K-15. Typical configuration of the stator and turbulator

K.3.4 FUEL SYSTEM

A method of fuel pressurization is required to deliver the proper amount of fuel to the spray nozzle for consistent atomization. The delivered fuel pressure is typically in the range of 100–120 lb/in^2 (0.689–0.827 MPa), and must maintain the desired pressure for the duration of a test. A suitable method of fuel pressurization is a pressurized fuel tank (see figure K-16). Alternatively, a fuel pump may be used if it can maintain the required pressure for the duration of a test with minimal fluctuation.

A fuel-pressure vessel, or tank, such as McMaster-Carr part number 1584K7 with a 15-gallon (56.8-Lliter) capacity, measuring 12 inches (305 mm) in diameter and 33 inches (838 mm) tall, or 35 inches (889 mm) tall including mounting base, can be used to contain the fuel. The tank has various fittings on the top, bottom, and sides to allow for connection of pipe fittings for filling, discharging, fuel-quantity level, pressure measurement, pressurization, and venting. Nitrogen is used to pressurize the headspace of the fuel tank. Solenoid or manual valves can be used to start and stop the flow of fuel, nitrogen, and vent gas. The headspace gas pressure is controlled by a precision regulator and monitored using a fuel-pressure gauge. A high-pressure translucent tube can be used for indicating the fuel level in the tank.

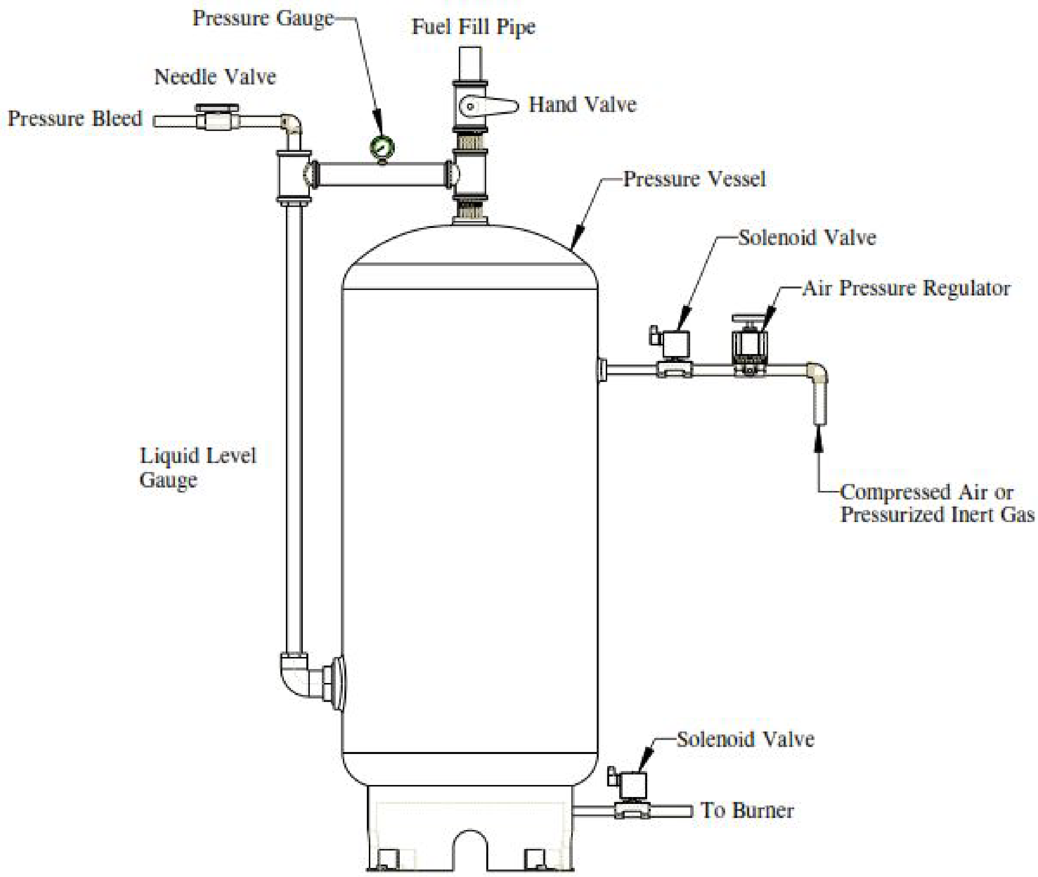


Figure K-16. Schematic of pressurized fuel-tank system

K.3.4.1 Fuel-Pressure Measurement Device

A suitable pressure gauge or transducer must be used to monitor the pressure inside the fuel tank, which is critical for establishing the proper flow of fuel into the fuel nozzle. The pressure gauge or transducer must have NIST (or equivalent) traceable certification with a ± 2% accuracy or less. If a pressure transducer is not used, digital gauges capable of reading in increments of 1 lb/in^2 (0.007 MPa) or less are recommended. If an analog gauge is used, it should be glycerin-filled to reduce needle flutter, and have an easily readable dial. The gauge must also have a working range appropriately suited for the range of fuel pressures typically used during tests. A suitable pressure transducer is supplied by Omega Engineering, part number PX329-150G5V. A suitable digital gauge is supplied by Omega Engineering, part number DPG1001B-500G. A suitable analog gauge is supplied by McMaster-Carr, part number 4053K23, with a 0–160 psi (0-1.1 MPa) pressure range.

K.3.4.2 Fuel Temperature

The fuel temperature must be maintained at 42° ± 10°F (5.5° ± 5.5°C) for the duration of a test. This can be achieved by constructing a heat-exchange system, as described later in this appendix.

K.3.4.3 Fuel Tube

The fuel tube in the Sonic burner is designed to allow both the fuel nozzle and the airflow to be aligned with the axis of the draft tube. This is accomplished by creating two bends in the section of the fuel tube that enters the back of the burner (see figure K-17). The tube is constructed from schedule-80, thick-wall, 0.125-inch (3.175-mm) steel pipe with an OD of 0.405-inch (10.287-mm), an inside diameter of 0.215-inch (5.461-mm), and a wall thickness of 0.095-inch (2.413-mm). The tube is cut to a length of approximately 21.5 inches (546.1 mm); a section of the outer wall is removed on a lathe to fit the fuel tube through the keyless bushing that holds the tube in place. The outer diameter of the fuel tube is reduced to approximately 0.3750 inch (9.525 mm) for a length of 4 inches (101.6 mm) at one end. The tube is then shaped with a pipe bender according to the dimensions in the drawing. A die is used to thread both ends of the tube with 0.125-inch NPT pipe threads. Heavy duty 0.004-inch-thick (0.102-mm-thick) thread seal tape is wrapped on the pipe threads to prevent fuel leakage. A 1.375-inch-long (34.925-mm-long) brass fuel nozzle adapter is threaded onto the front end of the fuel tube where the fuel nozzle will be attached. A keyless bushing (Fenner Drives p/n 6202109) is used to hold the back end of the fuel tube in place. A pipe fitting is attached to the back end of the fuel tube to connect the pressurized fuel system to the fuel tube.

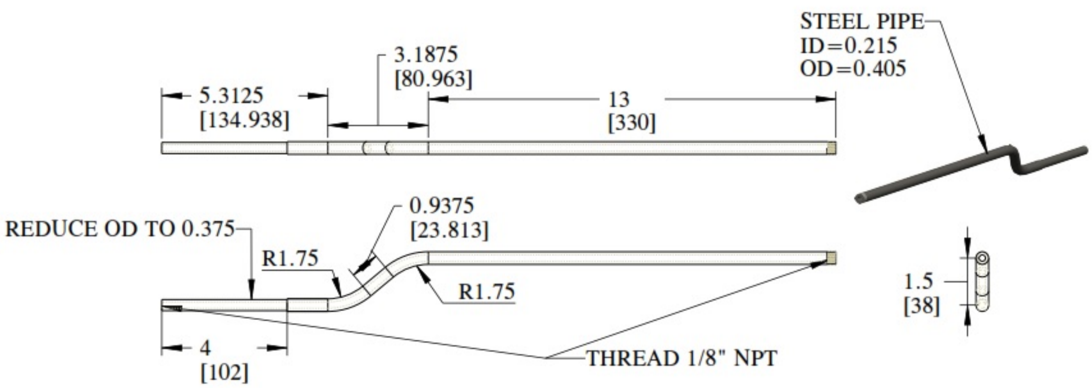


Figure K-17. Schematic of the fuel tube

K.3.4.4 Fuel Nozzle

The fuel nozzle for the Sonic burner should be an 80-degree, solid conical spray pattern, oil burner nozzle. The nozzle flow rate will depend on the test method. The rated flow rate provided by the manufacturer is achieved when applying a 100 lb/in^2 (0.71 MPa) pressure to the nozzle. If a different flow rate is desired, the pressure can be adjusted accordingly to achieve a wide range of flow rates. In general, the flow rate is related to the pressure by:

$$F_d = F_r \sqrt{P_d / P_r} \tag{K-2}$$

In which F_d is the desired flow rate, F_r is the rated flow rate, P_d is the desired pressure, and P_r is the rated pressure, typically 100 psig (0.71 MPa). For example, if a 5.5-gal/hr (20.8 L/hr)-rated nozzle is operated at 120 lb/in^2 (0.83 MPa), a flow rate of 6.0 gal/hr (22.7 L/hr) will be achieved. A Delavan, 80-degree, solid-spray pattern (B-type) fuel nozzle has been found suitable for this application. A suggested nozzle flow rating can be found in the particular test method for which the burner is being used.

K.3.4.5 Nozzle Adapter

The fuel-nozzle adapter is a brass fitting 1.375 inches (34.9 mm) in length with a 0.125-inch NPT thread on the inlet side and a 0.5625-inch 24 Unified Fine Thread (UNF) where the nozzle attaches (see figure K-18).

Figure K-18. Fuel nozzle and brass adapter

K.3.4.6 Fuel

Use jet fuel (JP-8, Jet A, or their international equivalent), or ASTM K2 fuel (Number 2 grade kerosene) to yield the desired fuel flow rate within the specified pressure range for the test method being performed. Diesel fuel may also be used; however, the test condition may be more severe.

K.3.5 IGNITION SYSTEM

The fuel/air charge will be ignited by a high-voltage arc produced by a spark plug positioned in the top of the combustion cone in the vicinity of the fuel-spray nozzle. The high-voltage is supplied by an alternating current (AC) powered transformer, which produces a direct current spark.

K.3.5.1 Ignition Transformer

A high-voltage oil burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone.

K.3.5.2 Spark Plug

The spark plug uses a standard (14 mm) diameter thread size with a thread pitch of 1.25 mm. The threaded segment of the spark plug is 0.36 inch (9.1 mm) in length. The exposed portion of the central insulator measures 0.70 inch (17.8 mm) in length. The spark-plug gap must be opened to 0.100 inch (2.5 mm) to consistently ignite the fuel/air charge in the burner cone (see figure K-19). A suitable spark plug is manufactured by Champion Products®, manufacturer part number RJ19LM, and can be purchased through Grainger (www.Grainger.com), part number 12U891.

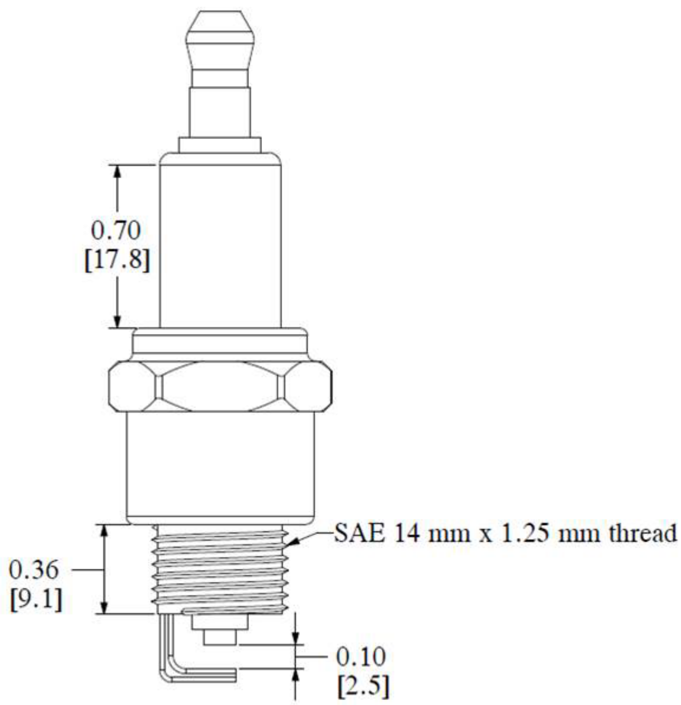


Figure K-19. Dimensioned drawing of a spark plug

K.3.6 HEAT-EXCHANGE SYSTEM

A heat-exchange system is used to regulate the temperature of the burner-inlet air and fuel because the flow rate of each is dependent on the density of the air and fuel. A schematic of a suitable heat-exchange system is displayed in figure K-20. The cooling system can be constructed from an insulated cooler or a chest freezer with temperature-control capability. The fuel travels through coiled copper tubing in the cooling bath and out to the burner. The air is cooled in a heat exchanger, such as McMaster-Carr part number 43865K78, which has cooling fluid traveling through the outer shell, removing heat from the air. The cooling fluid is circulated in a closed loop from the cooler to the heat exchanger using a submersible pump. The exact dimensions of the copper coils and the flow rate of the water pump will be dependent on the particular conditions in the laboratory.

Alternate methods, such as active heating and cooling systems, can be used, allowing greater precision, but they may be more costly. Uninsulated or long fuel/inlet air supply lines can create difficulties in maintaining proper fuel/inlet air temperatures.

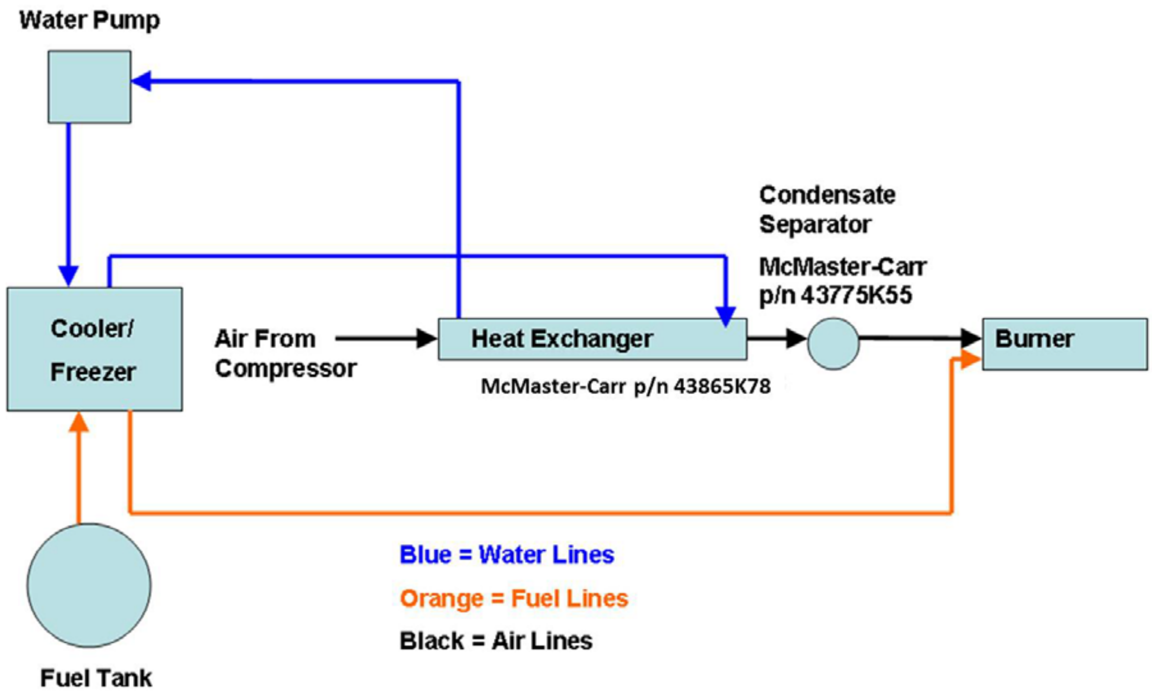


Figure K-20. Schematic of air/fuel heat-exchange system

K.3.7 BURNER CONE

A 12 ± 0.125-inch (305 ± 3-mm) burner-extension cone is fitted to the end of the draft tube. The cone is constructed from 16-gauge, American Iron and Steel Institute (AISI) type 310 stainless steel. The cone exit plane must be 6 ± 0.250 inches (152 ± 6 mm) high and 11 ± 0.250 inches (280 ± 6 mm) wide with a thickness of 0.0625 ±0.015 inch (1.59 ± 0.381 mm). The welded seam connecting the burner cone mounting flange and burner cone extension should align with the end of the burner draft tube. Refer to figures K-21 and figure K-22 for detailed drawings. The hot and cold cycling that occurs during typical testing can cause the cone exit plane dimensions to shift from warpage. It is critical to periodically check the cone exit plane dimensions to ensure they remain within the specified tolerances. It is recommended this check be performed at the beginning and end of each day the burner is operated. A cone found to be out of tolerance should be repaired or replaced before continuing operation of the burner. A reinforcement frame may be added to the cone to reduce the potential of cone warpage. Refer to figure K-23 for detailed drawings.

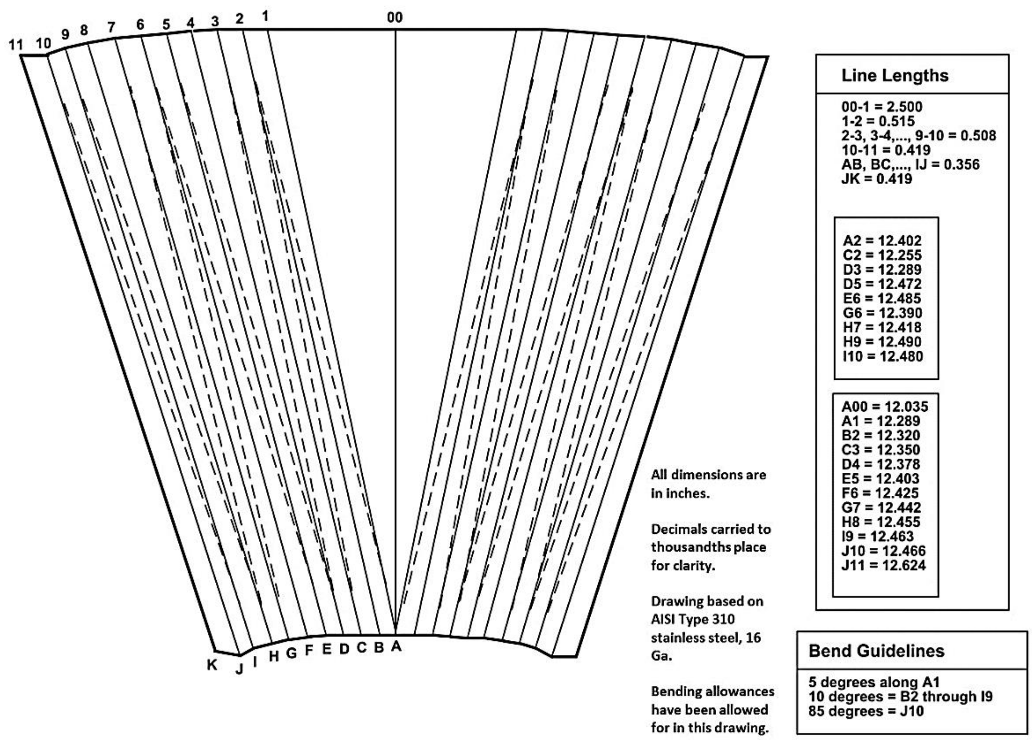


Figure K-21. Burner cone layout and bending pattern

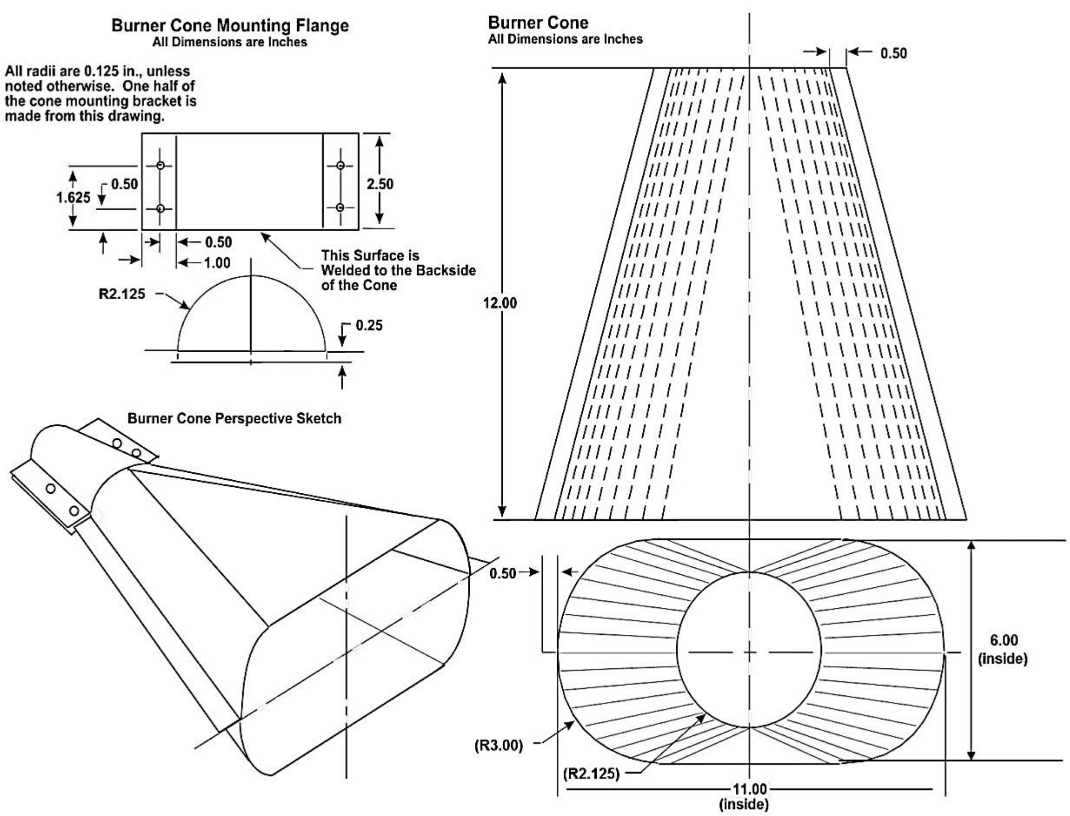


Figure K-22. Burner cone details

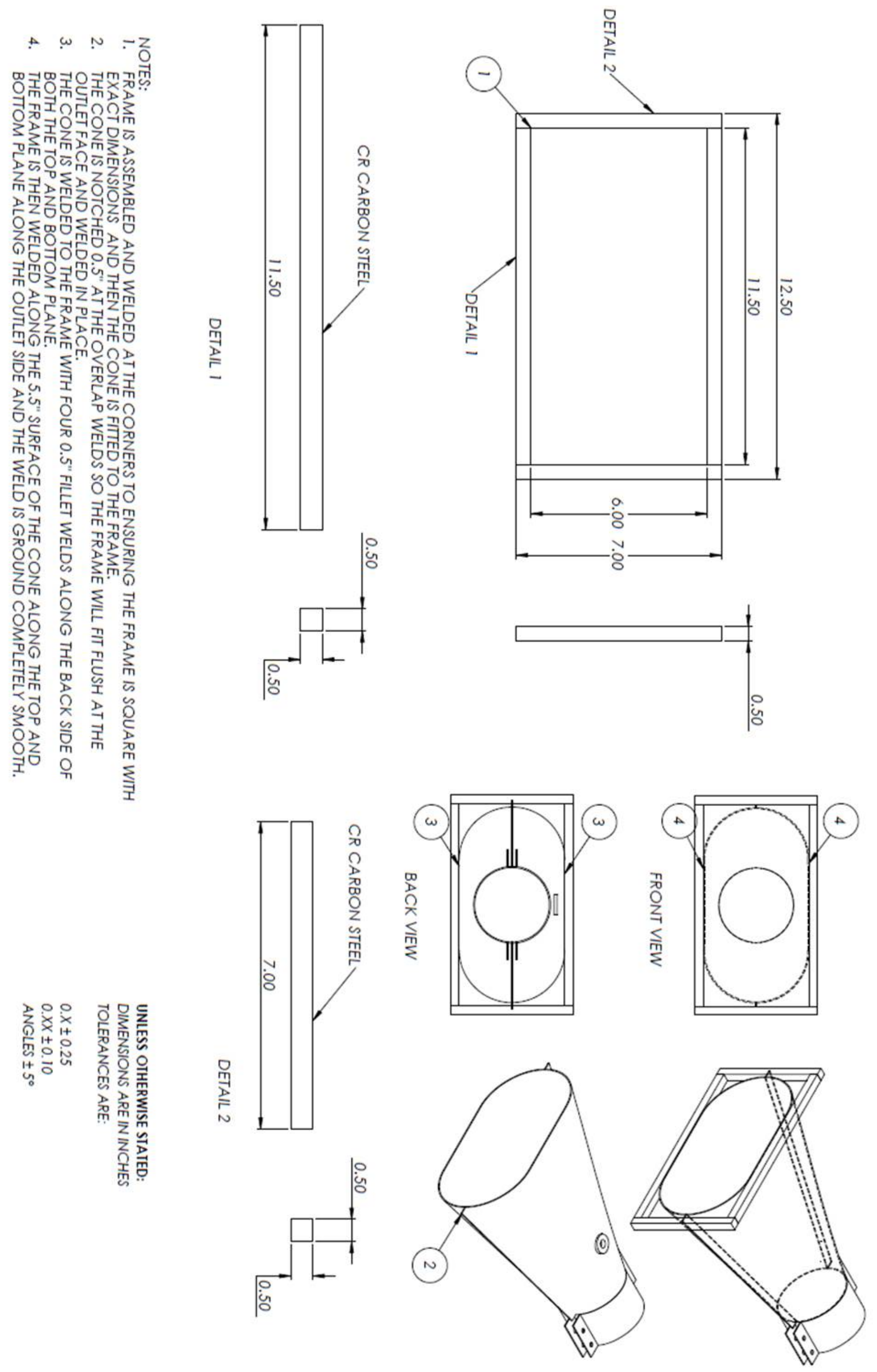


Figure K-23. Burner cone reinforcement frame

K.3.7.1 Threaded Boss for Spark Plug

A threaded boss must be fabricated from AISI type 310 stainless steel. The cylindrical boss must measure 1.125 inches (28.58 mm) in diameter, with a thickness of 0.250 inches (6.4 mm). The boss must be threaded using an SAE standard 14 mm spark-plug tap (see figure K-24). The threaded boss must be welded to the top side of the burner extension cone for acceptance of the spark plug used to ignite the fuel charge (see figure K-25).

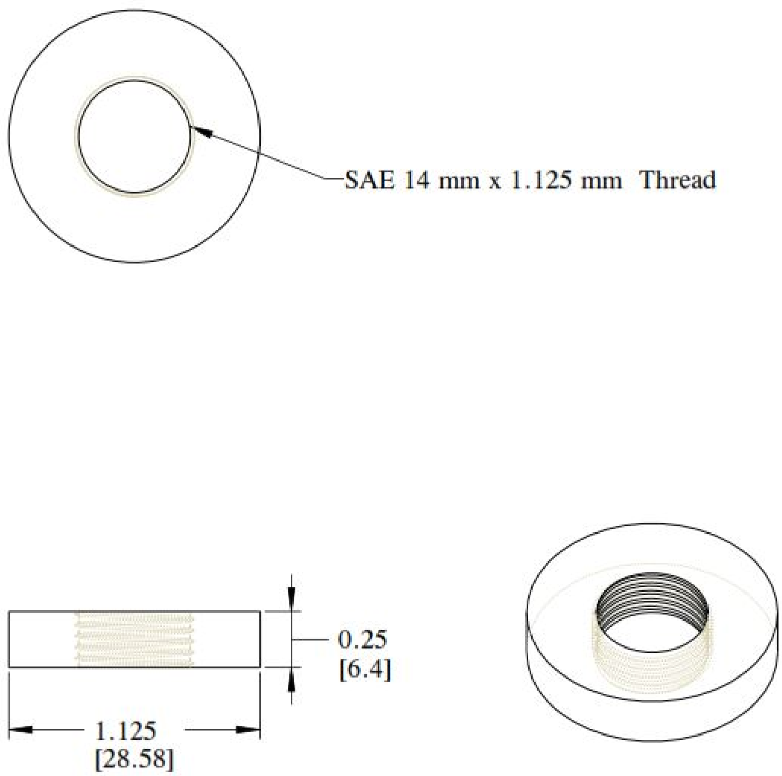


Figure K-24. Threaded boss

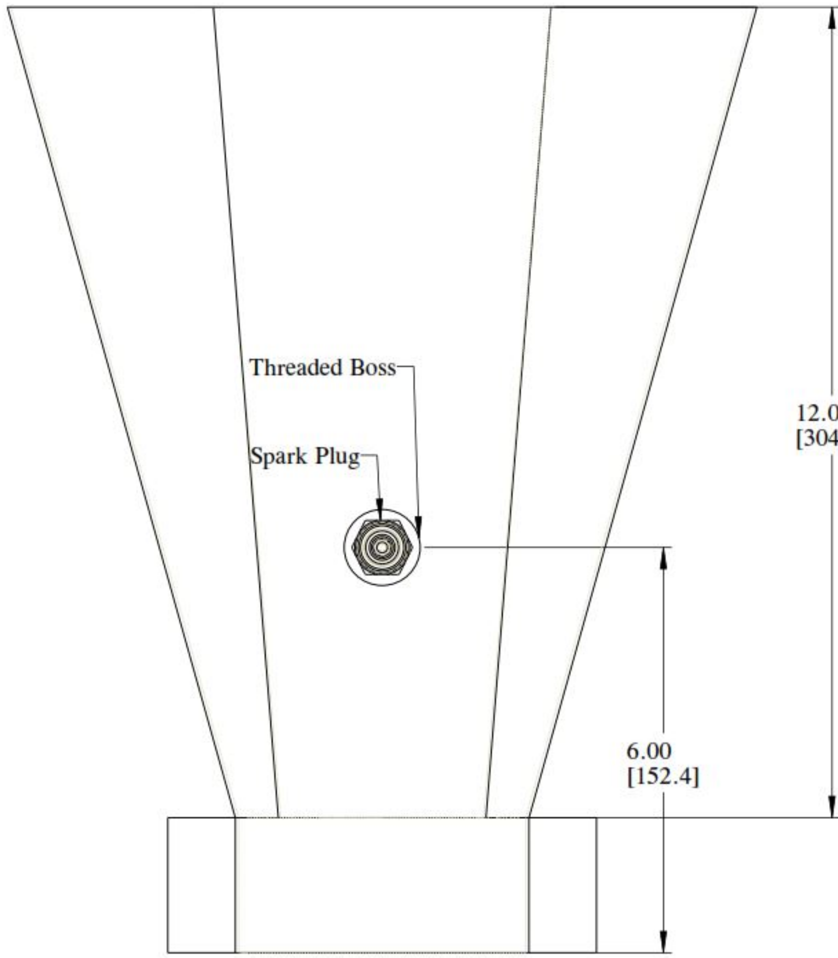


Figure K-25. Location for welding threaded boss to cone

K.4. MEASUREMENT OF ADJUSTABLE BURNER PARAMETERS

K.4.1 MEASUREMENT LOCATIONS

Accurate measurements of the burner inlet parameters are critical to proper operation. The measurement locations of the burner air and fuel supply are typically located just prior to entering the burner housing, or as near the burner housing as possible. The measurement locations of the burner air and fuel supply are indicated in figure K-26.

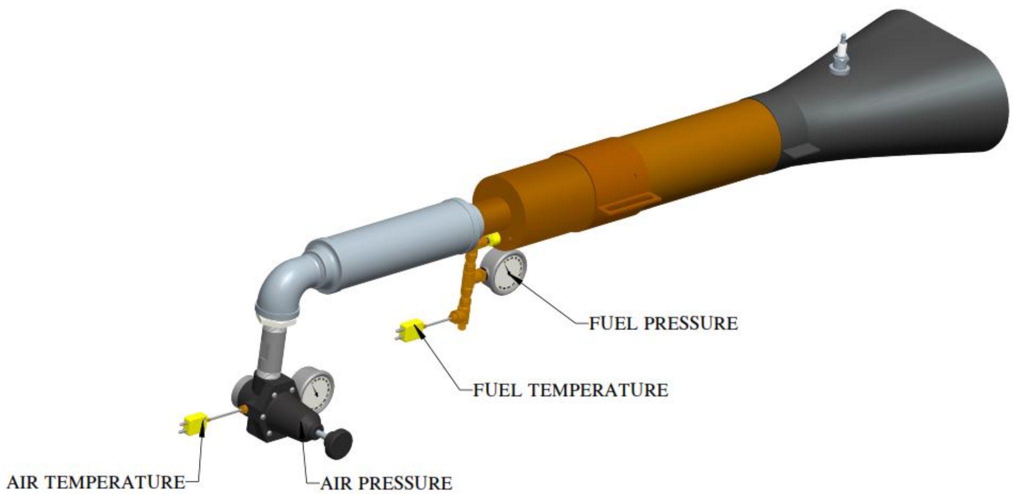


Figure K-26. Burner schematic showing inlet measurement locations

K.4.2 AIR PRESSURE

The sonic nozzle inlet pressure is measured with a suitable pressure gauge or transducer mounted just upstream from the sonic nozzle. The gauge or transducer should measure accurately in the range suited for the particular test method being conducted, with an accuracy of ± 2% maximum. Bourdon-type gauges and pressure transducers have proven to be suitable for this measurement (see details in the Air Pressure Gauge section above). A suggested nozzle flow rating can be found in the particular test method for which the burner is being used.

K.4.3 AIR TEMPERATURE

The burner air temperature is measured with a 0.125-inch (3.2 mm) diameter, insulation-packed, 310 stainless-steel sheathed, type K (chromel-alumel) grounded junction thermocouple with a nominal 24 AWG conductor. The thermocouple should be inserted into the air stream just upstream of the sonic nozzle with the tip located near the center of the air-supply stream. In some testing situations, flame radiation may occur on the inlet air lines, causing heating of the air and possible bursting of flexible hoses. It is important to shield all air lines with thermal wrapping to prevent an unsafe condition and to maintain steady air temperature.

K.4.4 FUEL PRESSURE

The burner-fuel pressure is measured with a suitable pressure gauge (see the Fuel Pressure Measurement Device section above) mounted in a T-connection in the fuel inlet line near the back of the burner. It is important that the measurement location be as close to the back of the burner as possible to accurately measure the fuel pressure at the point it enters the burner

K.4.5 FUEL TEMPERATURE

The burner fuel temperature is measured with a 0.125-inch (3.2 mm) diameter, insulation packed, 310 stainless-steel sheathed, type K (chromel-alumel) grounded junction thermocouple with a nominal 24 AWG conductor. The thermocouple should be mounted in a T-fitting such that the probe tip is located near the center of the fuel tube. In some testing situations, flame radiation may occur on the inlet fuel lines, causing heating of the fuel and possible bursting of flexible hoses. It is important to shield all fuel lines with thermal wrapping to prevent an unsafe condition and maintain steady fuel temperature.

K.5. MEASUREMENT OF BURNER OUTPUT

K.5.1 BURNER-FLAME CONSISTENCY VALIDATION

The objective of the burner-flame consistency validation is to ensure the burner is producing the required flame output to subject the test samples to the proper flame intensity. The Sonic burner is specialized equipment, using precision components assembled in a very specific configuration. This level of accuracy is a departure from previous burners, in which the internal components and configuration were not as tightly controlled. For this reason, previous burners used for flammability testing required time-consuming calibration procedures to help ensure the multitude of possible burner configurations were still producing the required flame intensity. With the Sonic burner, there is more reliance on the internal components and precise configuration to produce the correct flame output, thereby minimizing lengthy calibration procedures.

K.5.2 THERMOCOUPLE DEGRADATION

The thermocouples used for measuring the burner-flame temperature have been known to degrade over time. This is due to the transient nature of the burner flame, which produces rapid increases and decreases in temperature during measurement. These instantaneous fluctuations in temperature cause a reduction in the sensitivity of the instrument, resulting in a lower indicated reading. The difficulty with this degradation process is that it occurs gradually over a period of time, and currently there are no recommended guidelines for replacing the instruments after a specific number of exposure hours. This occurrence can often lead to suspicion that the burner is malfunctioning, triggering unnecessary adjustment of the burner equipment to compensate for the erroneous low temperature readings.

APPENDIX L—HR2 TEST APPARATUS AND EQUIPMENT DETAILS

This document contains information and supplemental material pertinent to referenced paragraphs. Drawings in this document are not mechanical but are used as a reference to illustrate component dimensions.

L.1. METHANE GAS (CH_4)

- Methane, CP Grade (99.0 percent) or product of similar specification or function has been found suitable.

L.1.1 HEAT RELEASE RATE APPARATUS

L.1.1.1 Insulation Material

- Type 814 FSK (3 pcf) Fiberglass Duct and Equipment Insulation [Johns Manville] or product of similar specification or function has been found suitable.

Johns Manville

717 17th St.

Denver, CO 80202 USA

Phone: (800) 654-3103

URL: http://www.specJM.com

L.1.1.2 High Temperature Gasket Material (above the second stage plate)

- Flexible Fiberglass Insulation Paper; McMaster-Carr P/N 9323K21 (1/8th inch thickness) or product of similar specification or function has been found suitable.
- Fiberfrax® 970 Series, Type J, Ceramic Fiber Paper (1/8th inch thickness) or product of similar specification or function has been found suitable.

Unifrax I LLC

600 Riverwalk Parkway

Suite 120

Tonawanda, New York 14150

Telephone: (716) 768-6500

Internet: www.unifrax.com

Email: info@unifrax.com

L.1.1.3 Low-Temperature Gasket Material (below the second stage plate)

- Rubber, silicone 0.125-inch (3.2 mm) thickness or product of similar specification or function has been found suitable in cooler areas of apparatus.

Table L-1. Component metal thickness and tolerances for cold rolled stainless steel and aluminum

0.25 inch Aluminum	Holding Chamber Door
	Lower Plenum Air Distribution Plate
0.036 ± 0.003 Aluminum	Exhaust Stack Sheathing/Shroud
0.125 ± 0.005-inch Stainless Steel	Sample Holder Retaining Rod
0.048 ± 0.004-inch Stainless Steel	Main Body/Main Body Flange
	Rear Globar Pan
	Holding Chamber
	Second-Stage Air-Distribution Plate
	Lower Plenum/Lower Plenum Flange
	Exhaust Stack Doubler
0.042 ± 0.004-inch Stainless Steel	Diamond-Shaped Mask
0.036 ± 0.003-inch Stainless Steel	Globar Reflector
	Sample Holder Injection Mechanism Plate
0.030 ± 0.003-inch Stainless Steel	Inner Radiation Doors (2)
0.018 ± 0.002-inch Stainless Steel	Pyramid-Shaped Exhaust Stack
	Sample Holder
	Sample Holder Retaining Ring
	Sample Holder Spring Plate
	Sample Holder Drip Pan

Table L-2. Tolerance table

(Except as noted)

1 PLACE	± 0.125 inch [3.2 mm]
2 PLACE	± 0.063 inch [1.6 mm]
3 PLACE	± 0.031 inch [0.8 mm]
ANGULAR TOLERANCE	± 1 degree
BEND TOLERANCE	± 1 degree

L.1.1.4 Holding Chamber

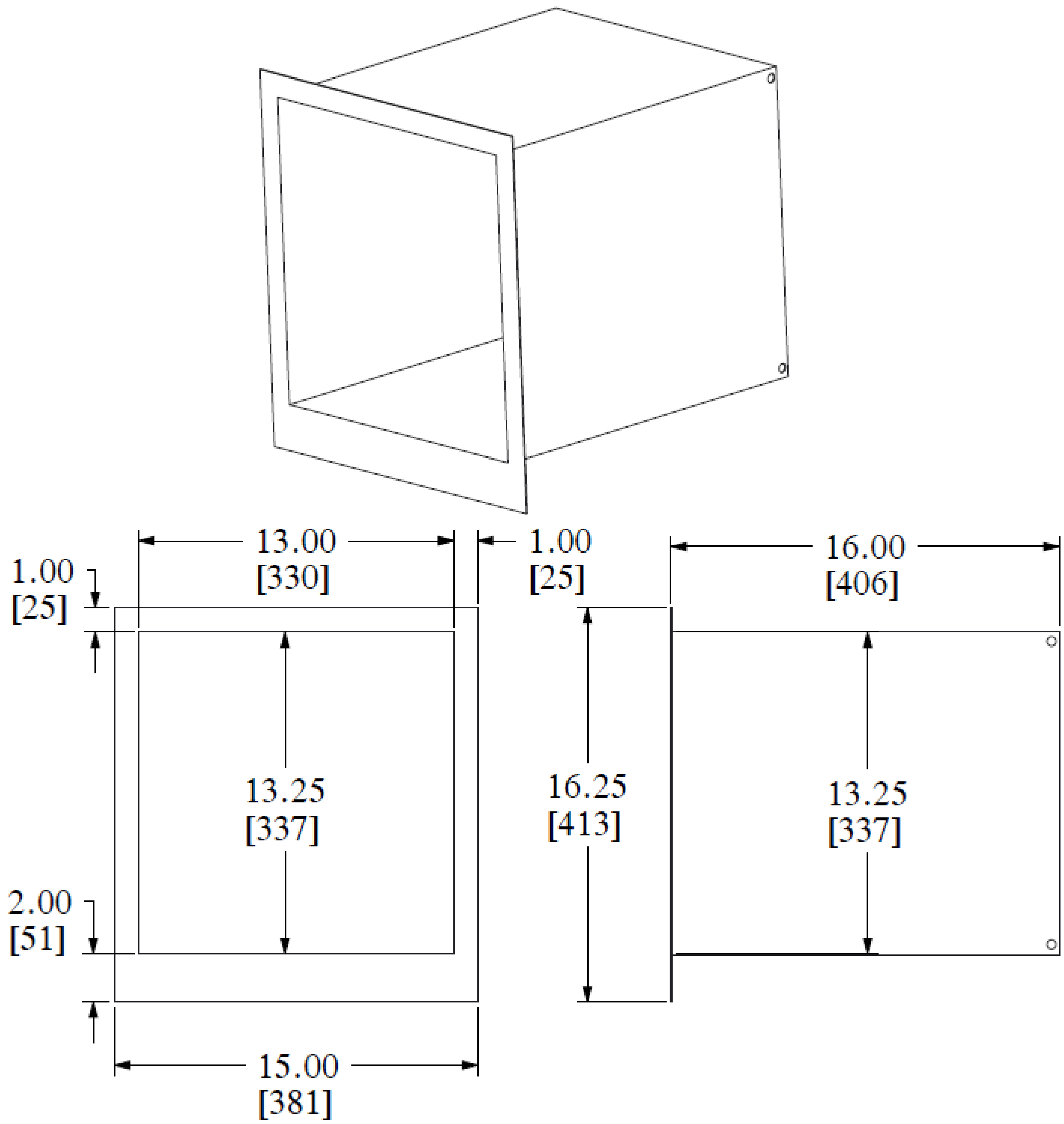


Figure L-1. Dimensioned drawing of the holding chamber

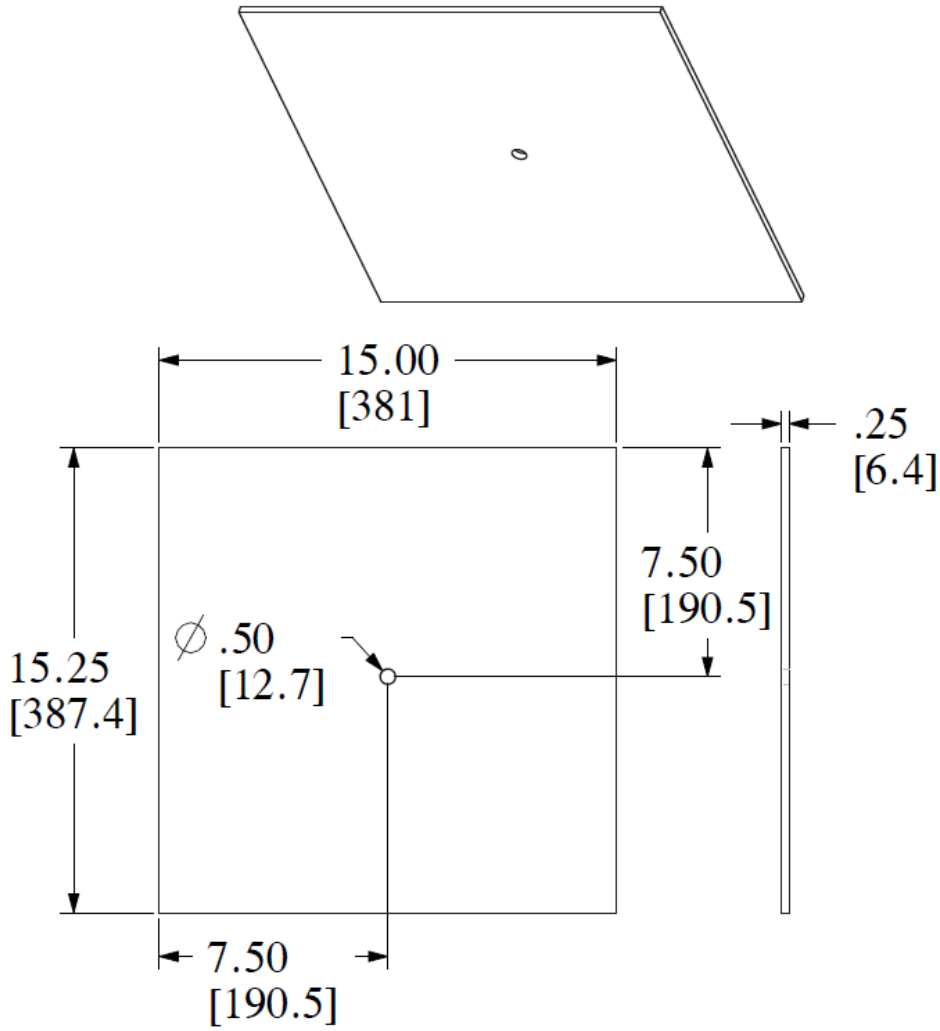


Figure L-2. Dimensioned drawing of the holding chamber door

L.1.1.5 Environmental Chamber

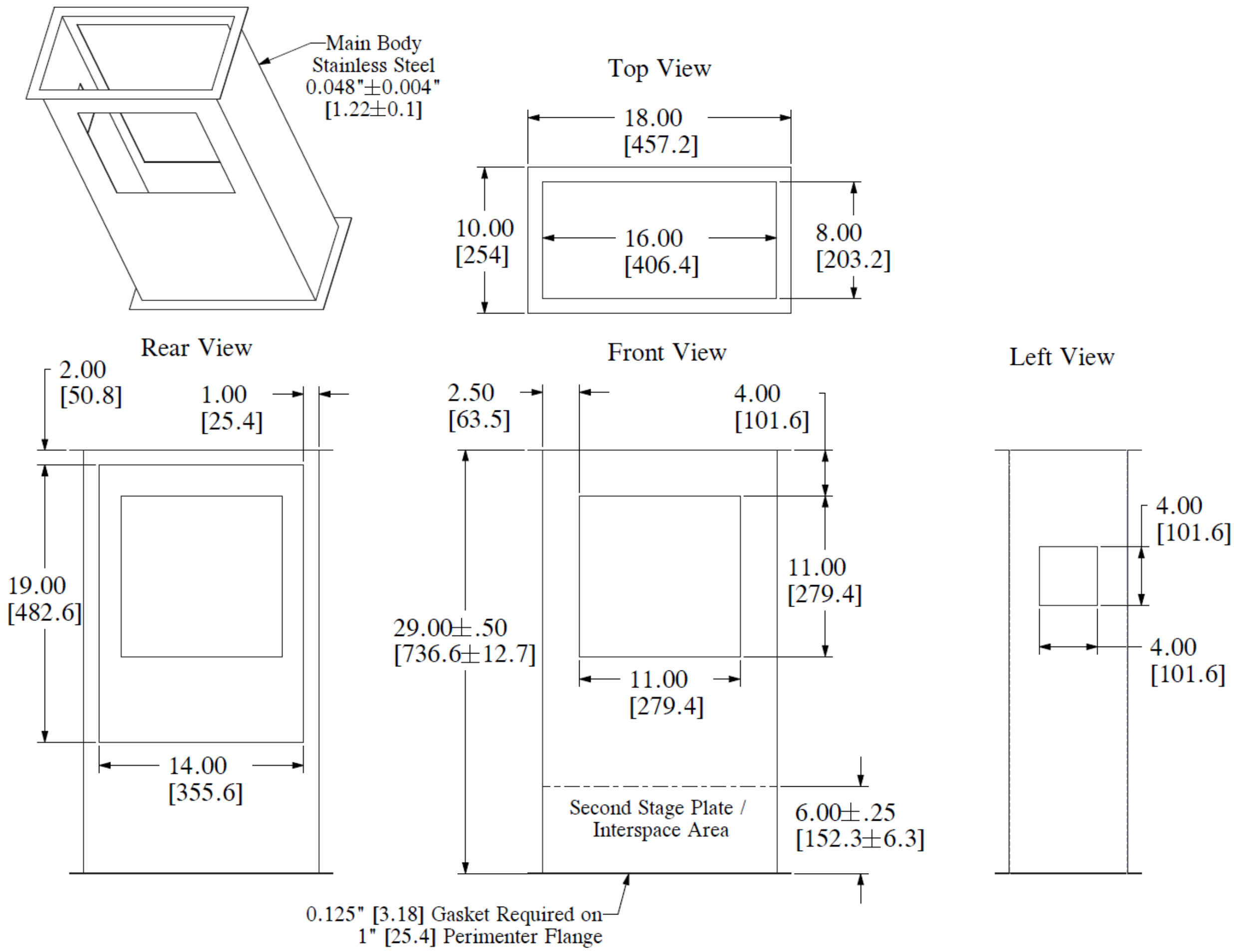


Figure L-3. Dimensioned drawing of the main body

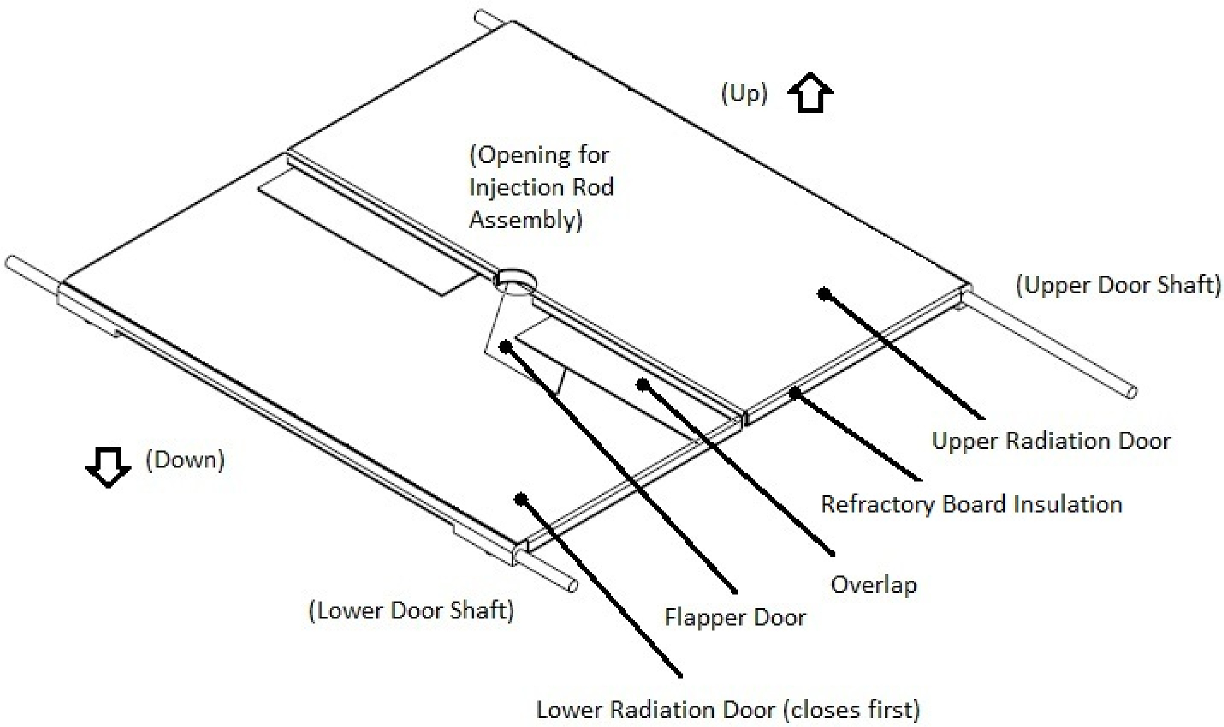
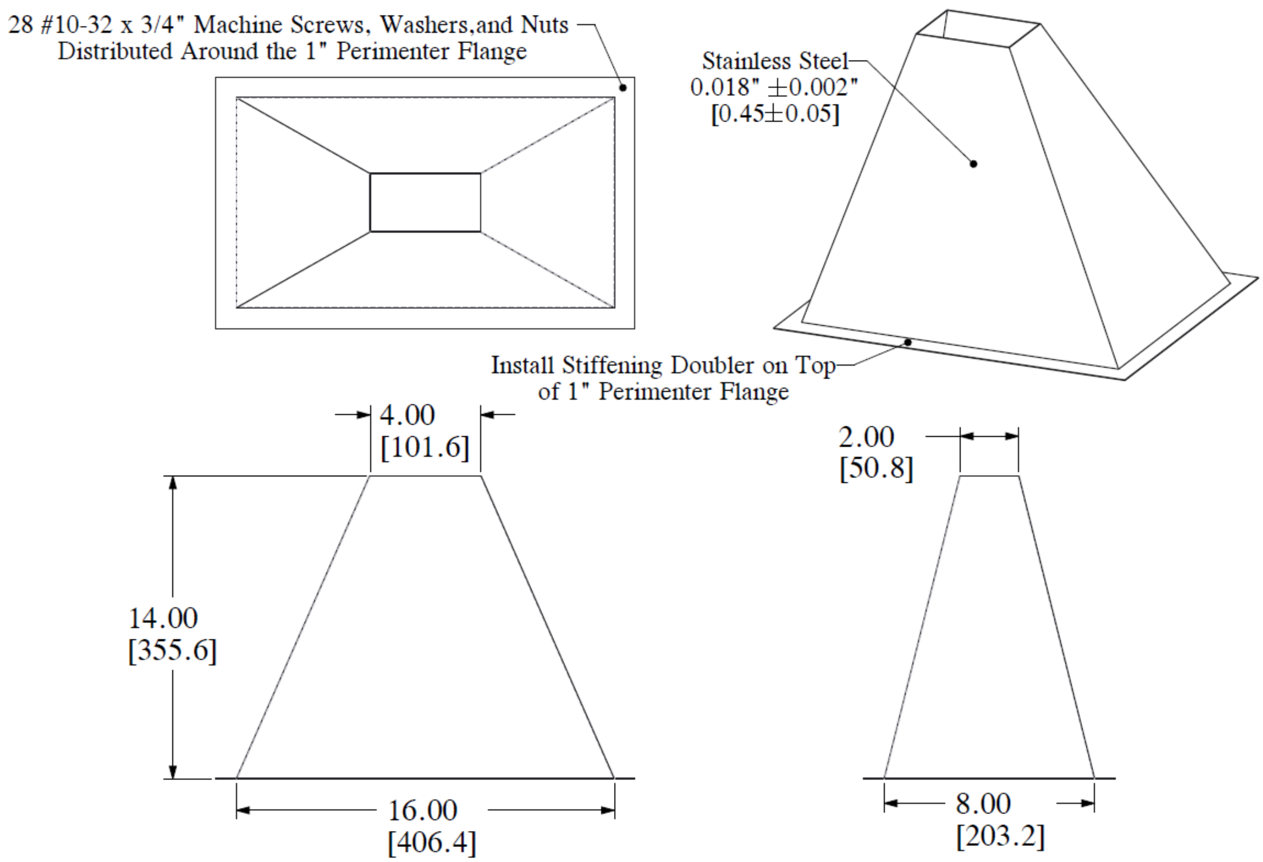


Figure L-4. Schematic of the radiation door assembly
(view from inside environmental chamber)

L.1.1.6 Pyramidal Section



NOTE: It is <u>extremely</u> important that the exhaust opening is square (90 degrees) in all four-corner dimensions.

Figure L-5. Dimensioned drawing of the pyramidal section

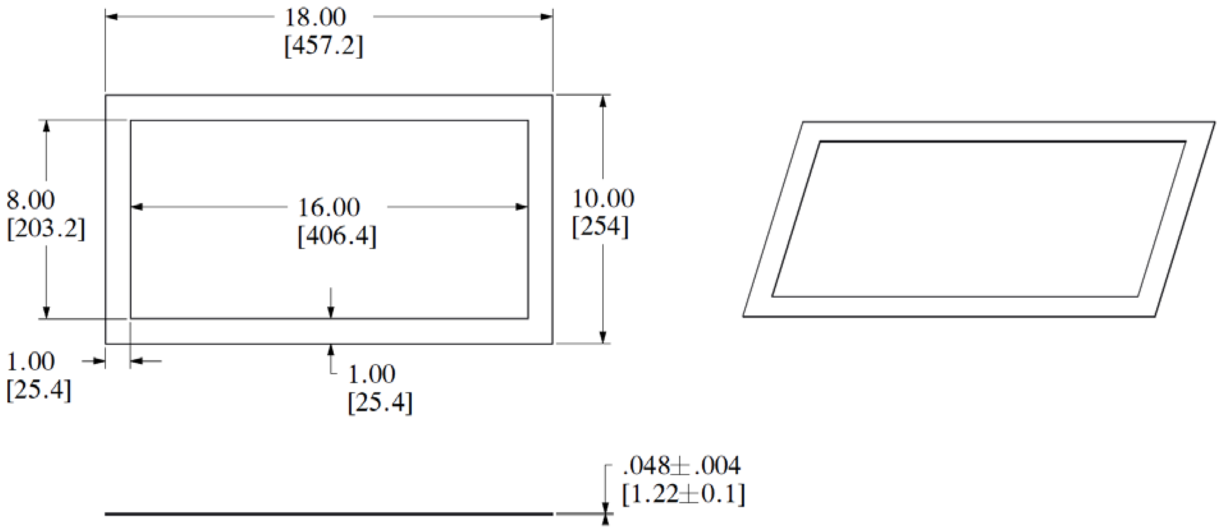


Figure L-6. Dimensioned drawing of the stiffening doubler

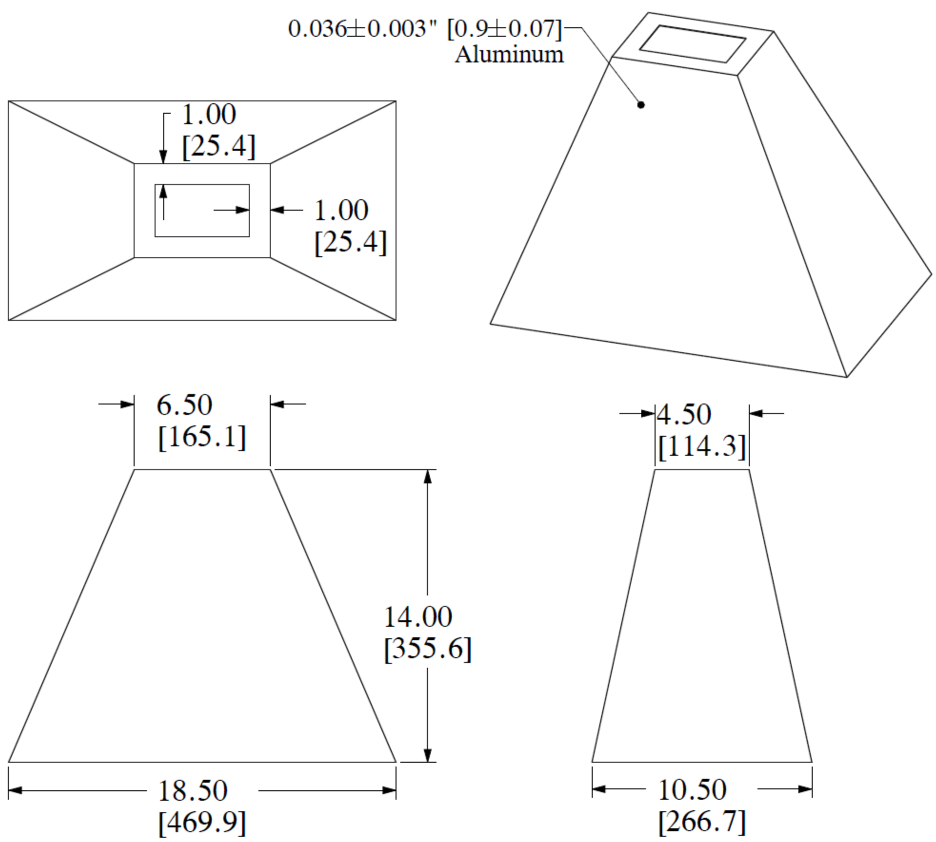


Figure L-7. Dimensioned drawing of the outer pyramidal shroud section

L.1.1.7 Radiation Source

- Globar [Kanthal Corp.] SDO-3-16-300-500-1.40-1515 or product of similar specification or function has been found suitable.

Sandvik Heating Technology USA

495 Commerce Drive, Suite 7

Amherst, NY 14228 USA

Phone: (716) 691-4010/Fax: (716) 691 – 7850

Email: sales.bethel@sandvik.com

URL: http://www.kanthal.com

- Marinite I Board 1-inch (25.4 mm) thickness or product of similar specification or function has been found suitable.

BNZ Materials, Inc.

400 Iron Horse Park

North Billerica, MA 01862

Phone: (800) 888-0061/Fax: (978) 663 – 2735

URL: http://www.bnzmaterials.com/contact-us/

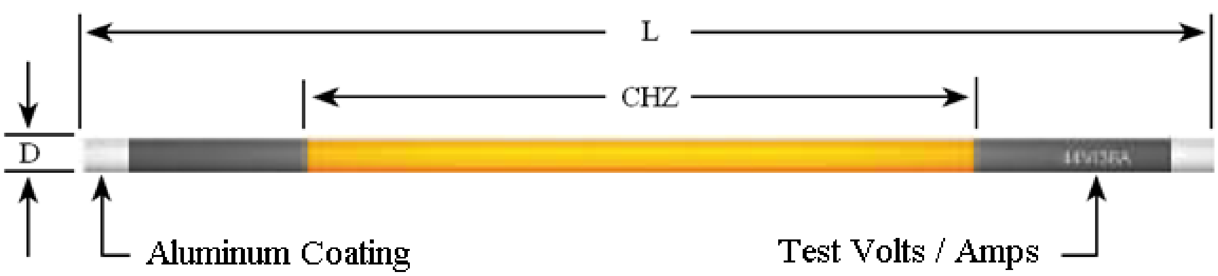


Figure L-8. Silicon carbide globar

L = 20 inches (508 mm)

D = 0.63 inch (16 mm)

CHZ = 12 inches (305 mm)

Nominal Resistance at 1000°C = 1.4 Ohms ± 15%

NOTE: All globar dimensions are approximate.

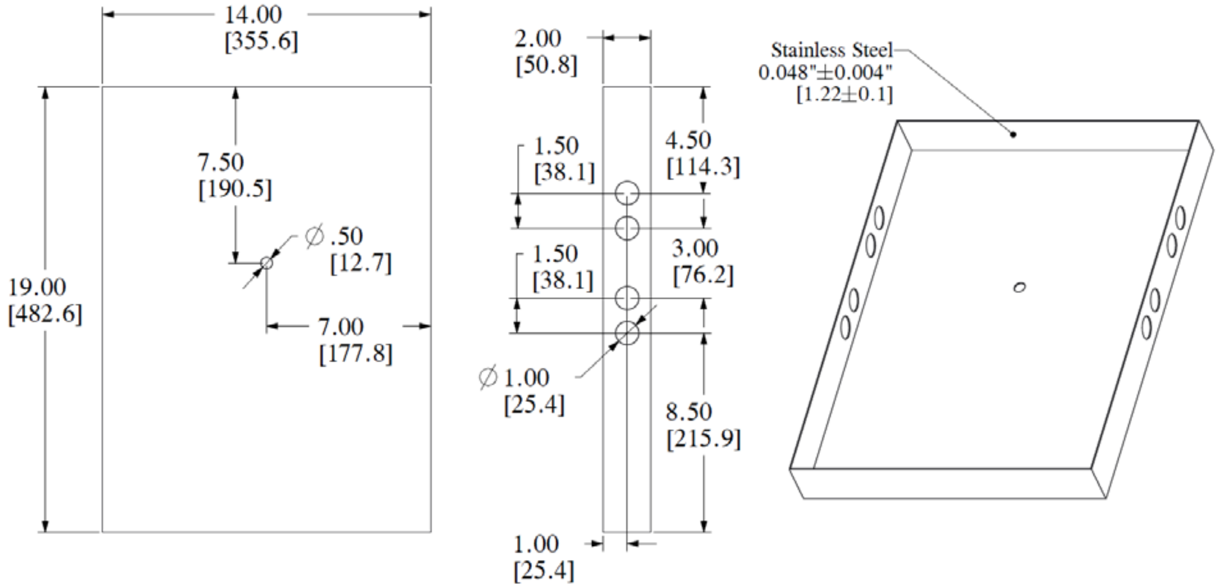


Figure L-9. Dimensioned drawing of the Globar pan

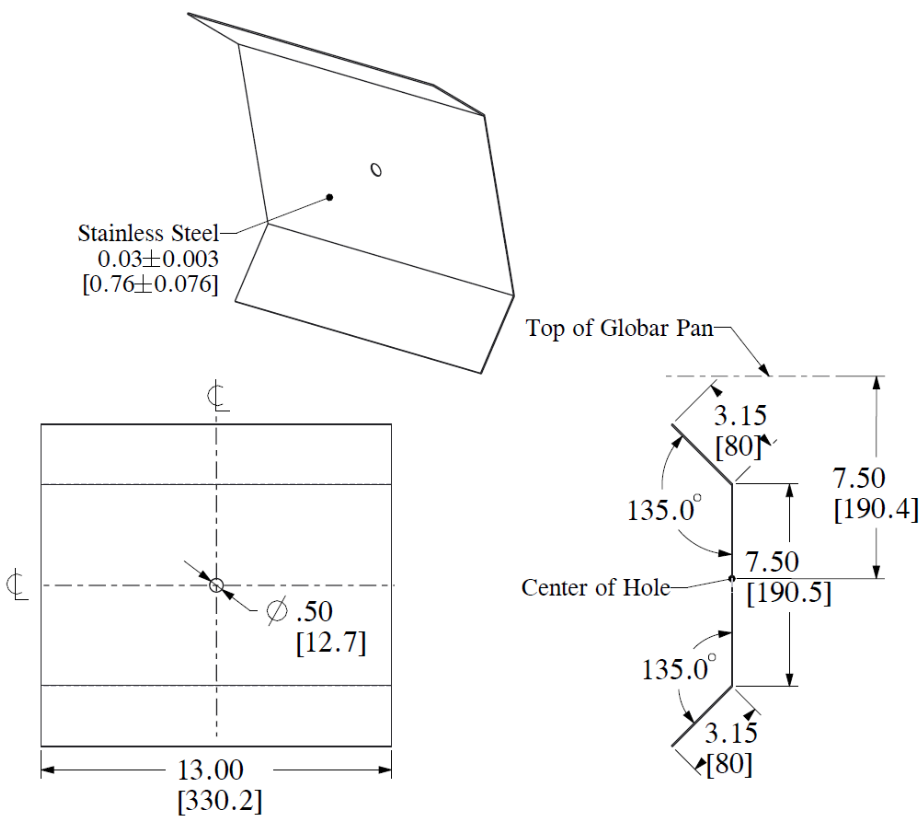


Figure L-10. Dimensioned drawing of the reflector plate

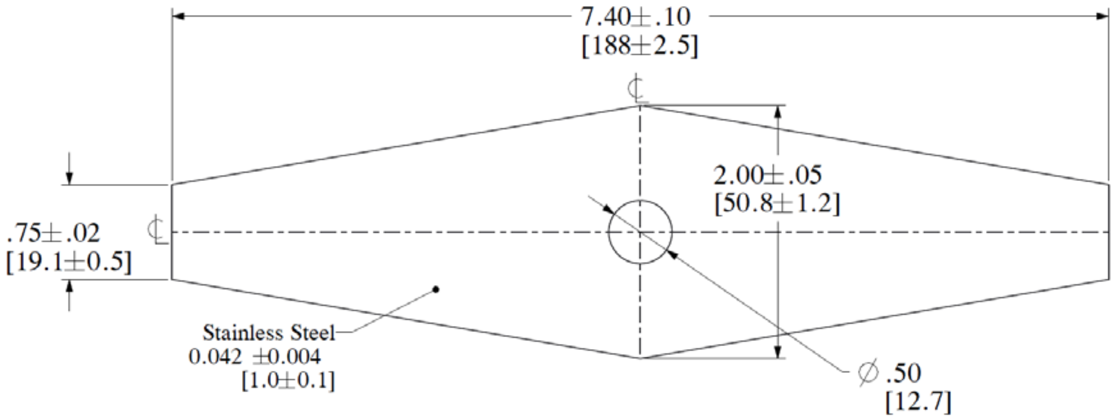


Figure L-11. Dimensioned drawing of the diamond-shaped mask

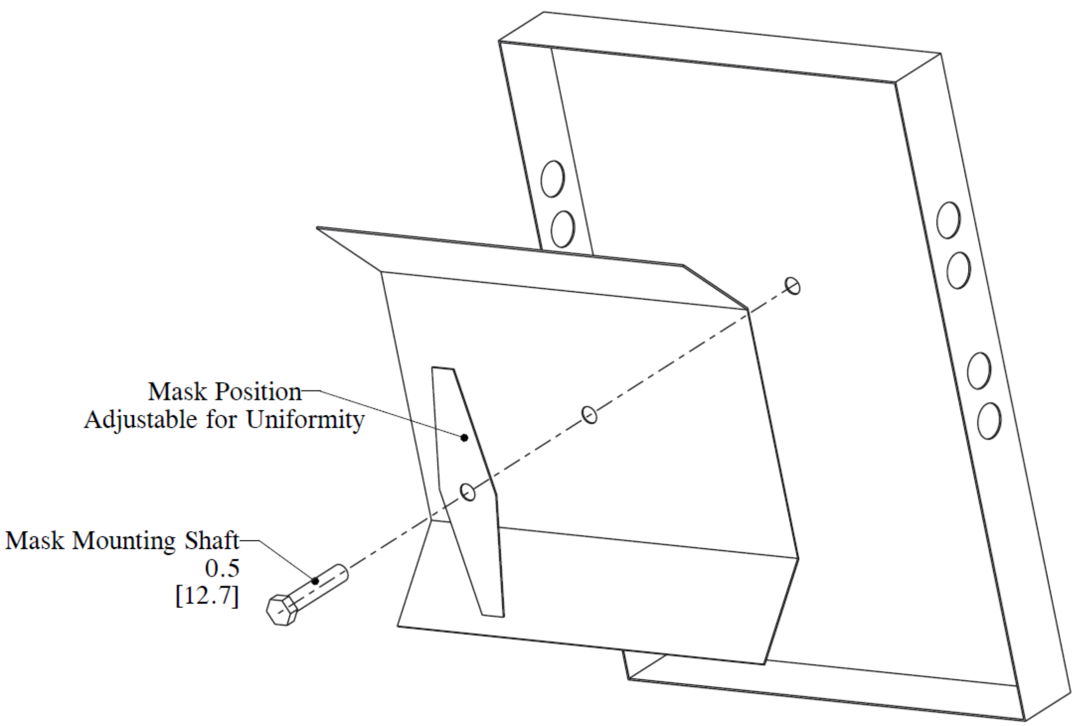


Figure L-12. Relative position of the mask, reflector plate, and Globar pan

L.1.1.8 Thermopile

- Ensure thermocouples read correctly when mounted into position. Grounding problems can have an impact on readings. The use of an insulating material may be required when mounting (electronically isolated).
- Thermocouple [Omega] KMQSS-062E-6 or product of similar specification or function has been found suitable.
- Thermocouple Grade Wire [Omega] TT-K-24 or product of similar specification or function has been found suitable.

Omega Engineering, Inc.

1 Omega Drive, Box 4047

Stamford, CT 06907-0047 USA

Phone: (203) 359-1660/Fax: (203) 359 – 7700

Email: sales@omega.com

URL: http://www.omega.com

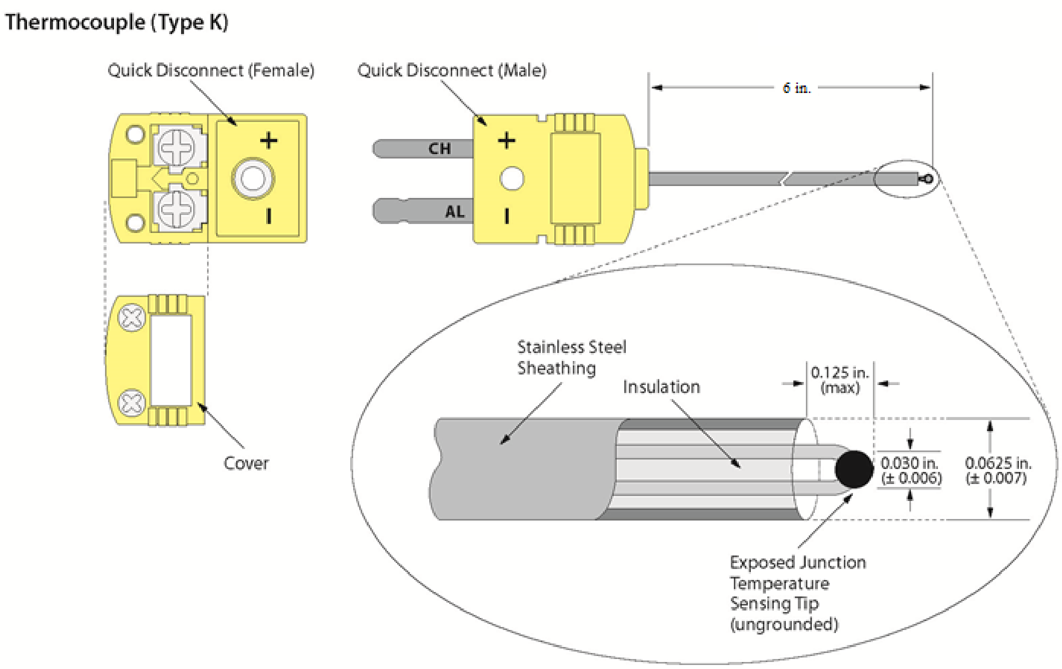


Figure L-13. Thermocouple

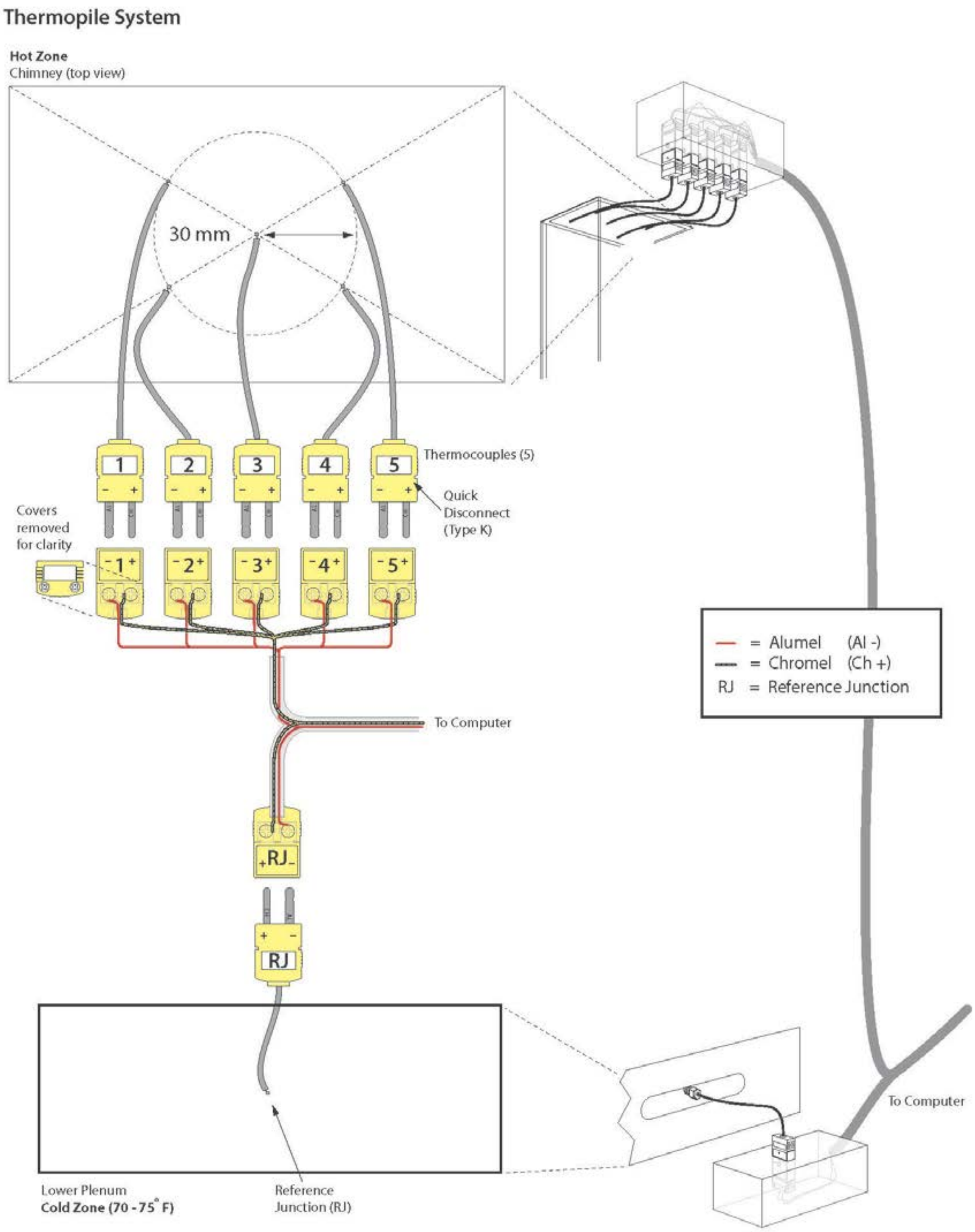


Figure L-14. Thermopile system

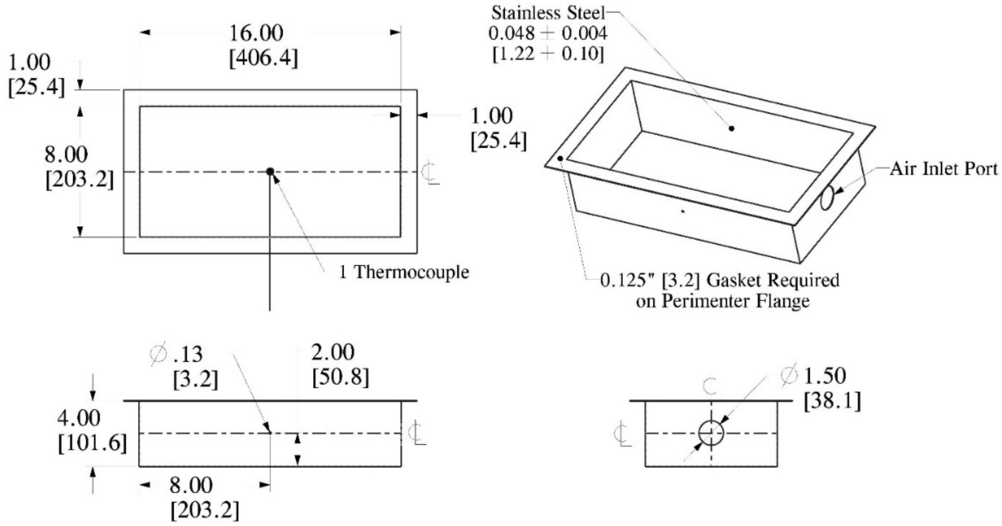


Figure L-15. Dimensioned drawing of the lower air plenum

L.1.1.9 Lower Pilot Burner

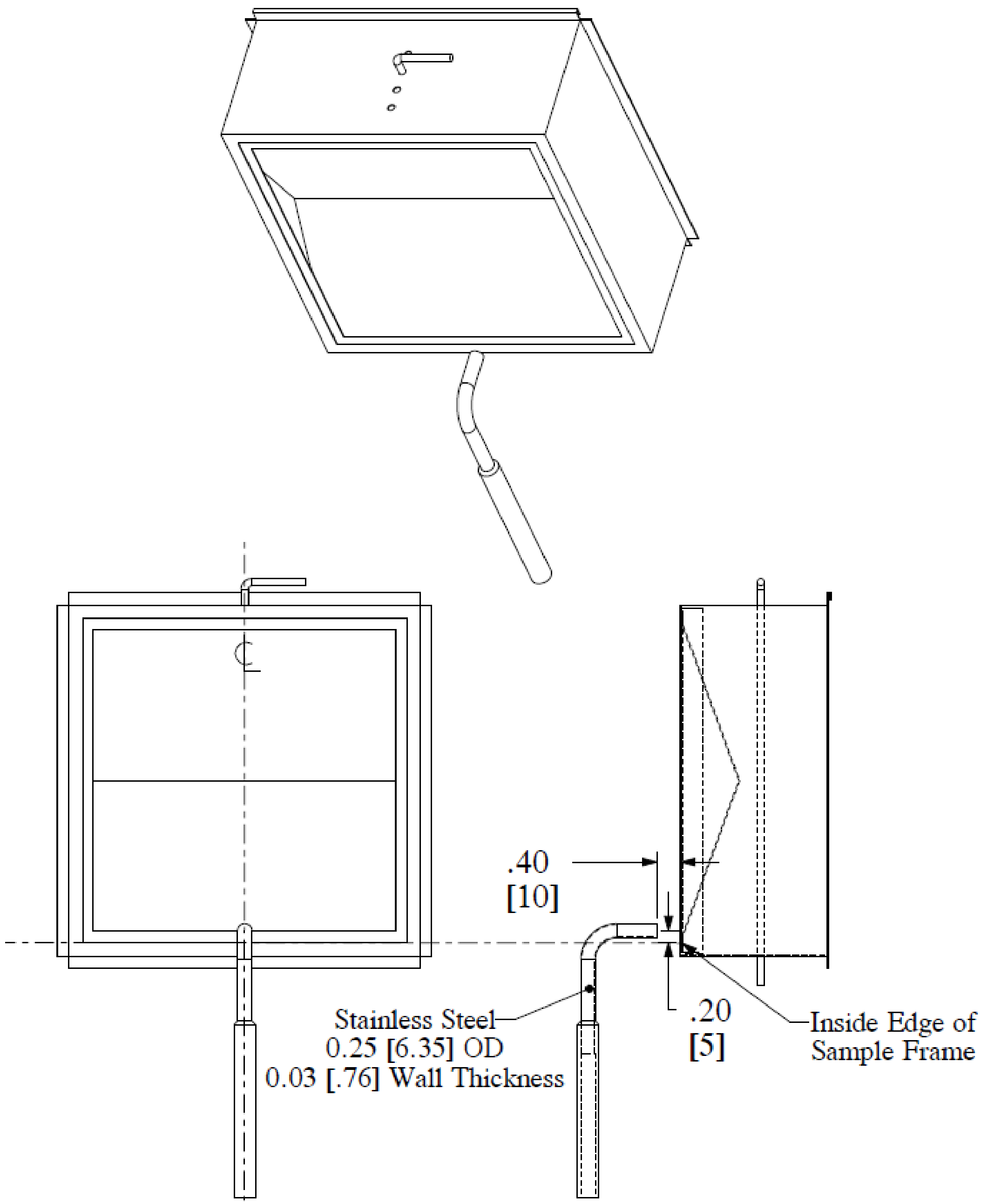


Figure L-16. Dimensioned drawing of the lower pilot burner relative to the sample holder

L.1.1.10 Upper Pilot/Calibration Burner

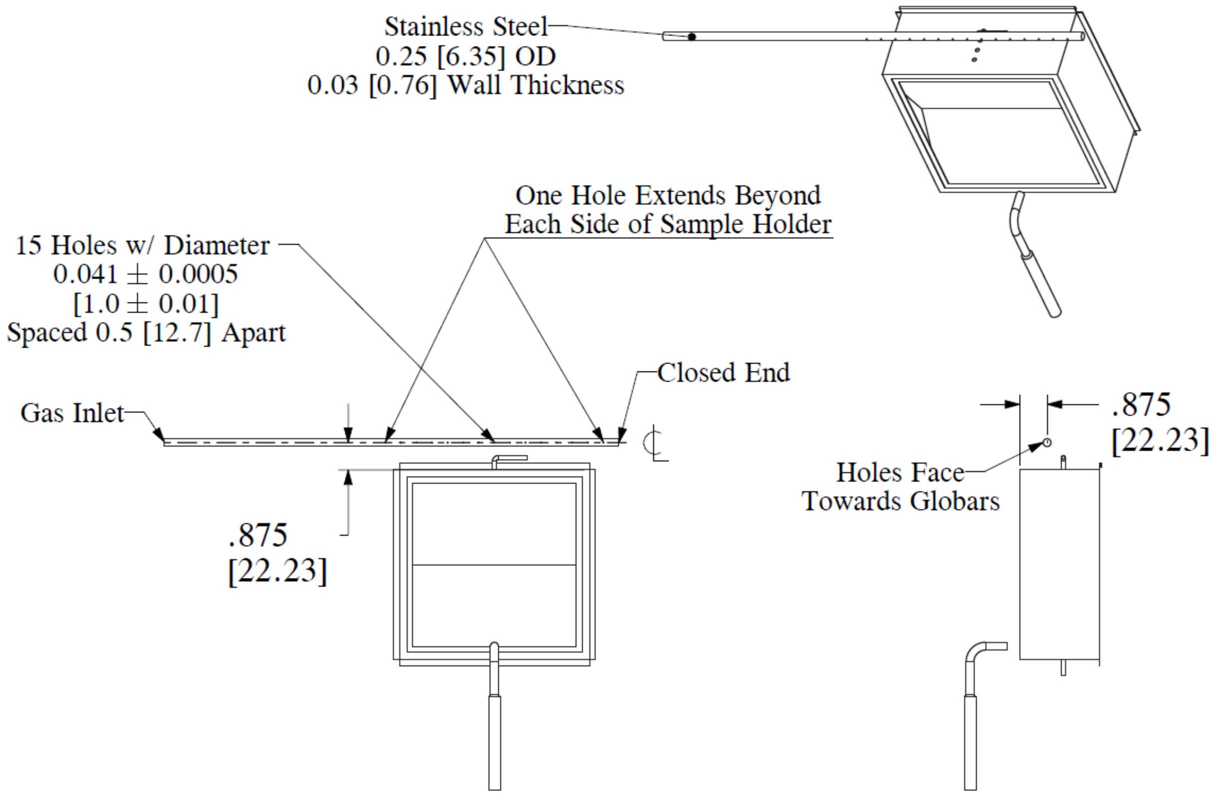


Figure L-17. Dimensioned drawing of the upper pilot burner relative to the sample holder

- Sierra Instruments Model C100L or product of similar specification or function has been found suitable (MFC: upper pilot mixing airflow controller).

  Part Number: C100L-NR-2-OV1-SV1-PV2-V1-S1-C3

  Typical Accuracy: ± 0.2% of F.S. for 2 to 20% F.S.

  ± 1% of setpoint for 20 to 100% F.S./2 second response time

  Range: 5000 sccm Air

  Fittings: 0.25-inch compression

  Seals: Viton

  SIERRA INSTRUMENTS, NORTH AMERICA

  5 Harris Court, Building L

  Monterey, CA 93940 USA

Phone: (831) 373-0200

URL: http://www.sierrainstruments.com

NOTE: Calibrate at 0°C and 760 mmHg (Torr) reference conditions.

L.1.1.10.1 Upper Pilot Burner Hot-Surface Igniter (HSI)

- Non-Porous High-Alumina Ceramic Rod; McMaster-Carr P/N 87065K42 or product of similar specification or function has been found suitable.

- Marlin Engineering Bracket P/N ME1240-45 or product of similar specification or function has been found suitable.

  Marlin Engineering, Inc.

  2200 Division Street, Suite A

  Bellingham, WA 98226 USA

  Phone: (360) 671-0155

  Email: sales@marlinengineer.com

  URL: http://www.marlinengineer.com

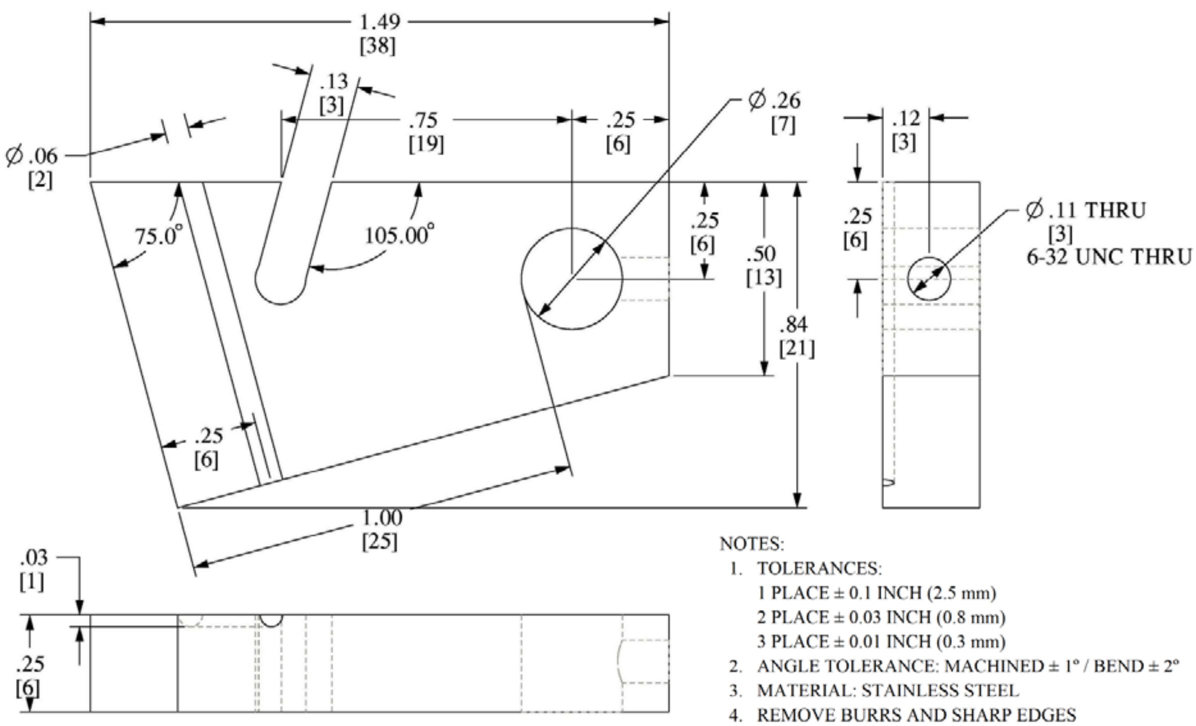


Figure L-18. Upper pilot burner HSI bracket

L.1.1.11 Igniter System

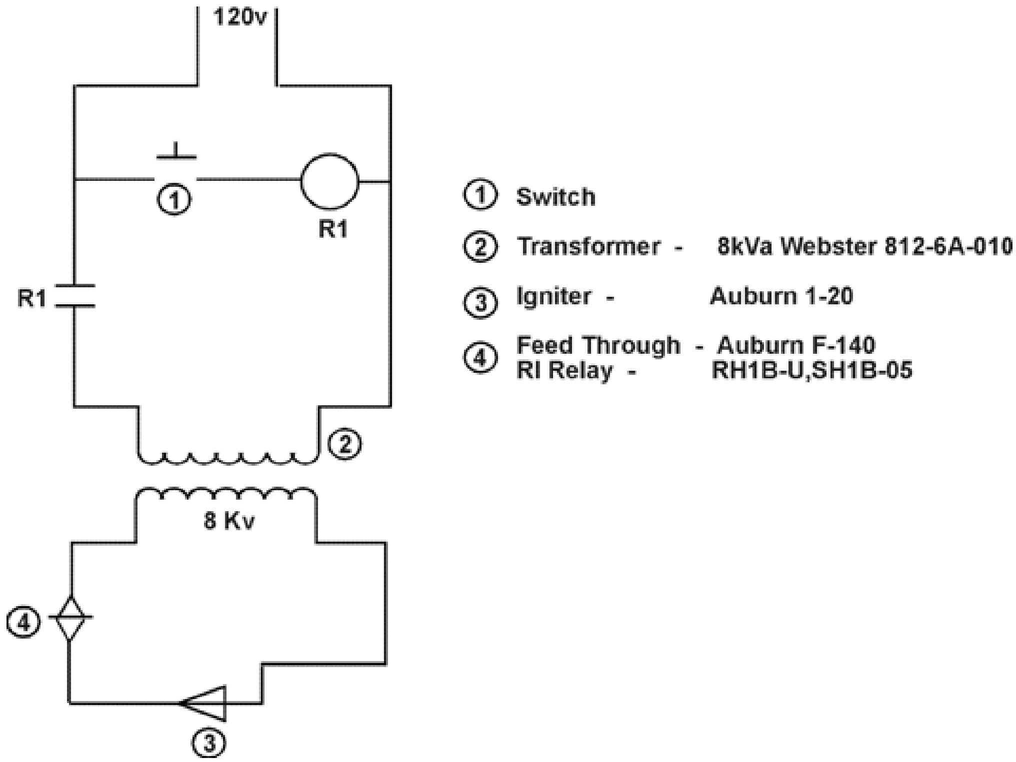


Figure L-19. Igniter schematic

L.1.1.11.1 Air Distribution System

- Mass Flow Controller [Sierra Instruments, Inc.] C100H1-NR-16-OV1-SV1-PV2-V1-S1-C3 or product of similar specification or function has been found suitable.

  Typical Accuracy: ± 2.0% of F.S.

  Range: 800 SLPM Air

  Fittings: 0.75-inch female NPT

  Seals: Viton

  SIERRA INSTRUMENTS, NORTH AMERICA

  5 Harris Court, Building L

  Monterey, CA 93940 USA

  Phone: (831) 373-0200

  URL: http://www.sierrainstruments.com

L.1.1.11.2 Air Distribution Plate

- Piping: PVC, 1.5-inch (38.1 mm) diameter, Schedule 40 pipe or product of similar specification or function has been found suitable.

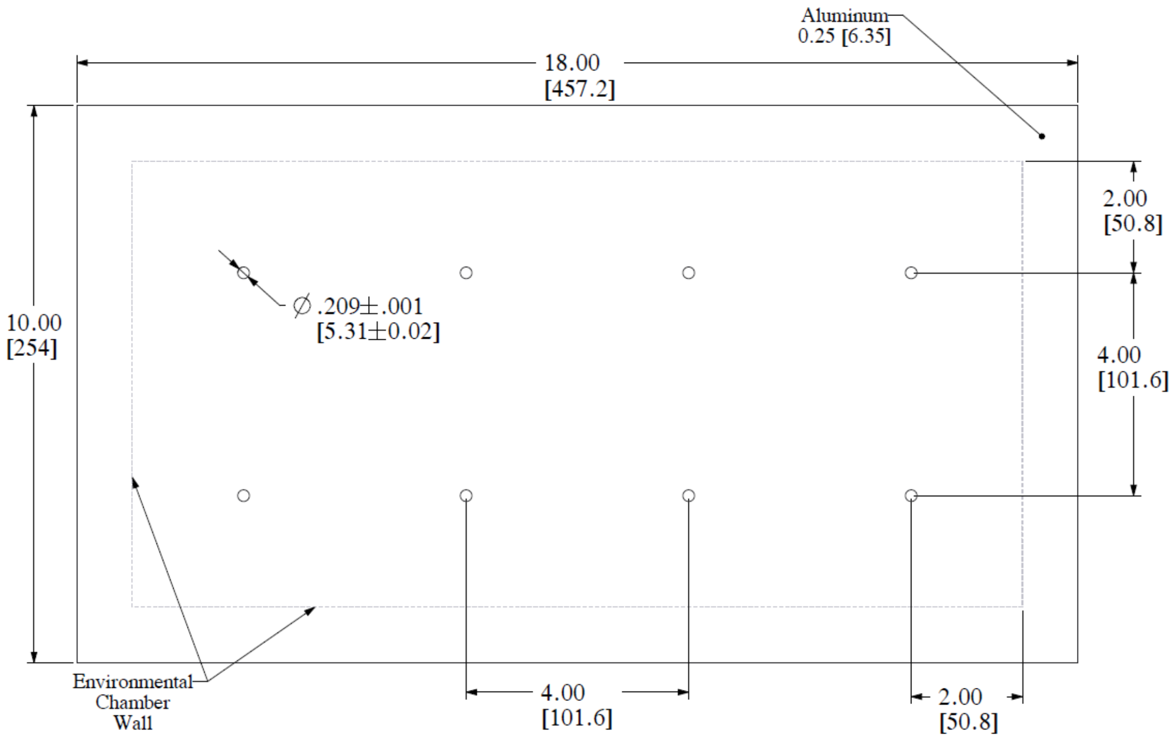


Figure L-20. Dimensioned drawing of the air-distribution plate

L.1.1.11.3 Second Stage Plate

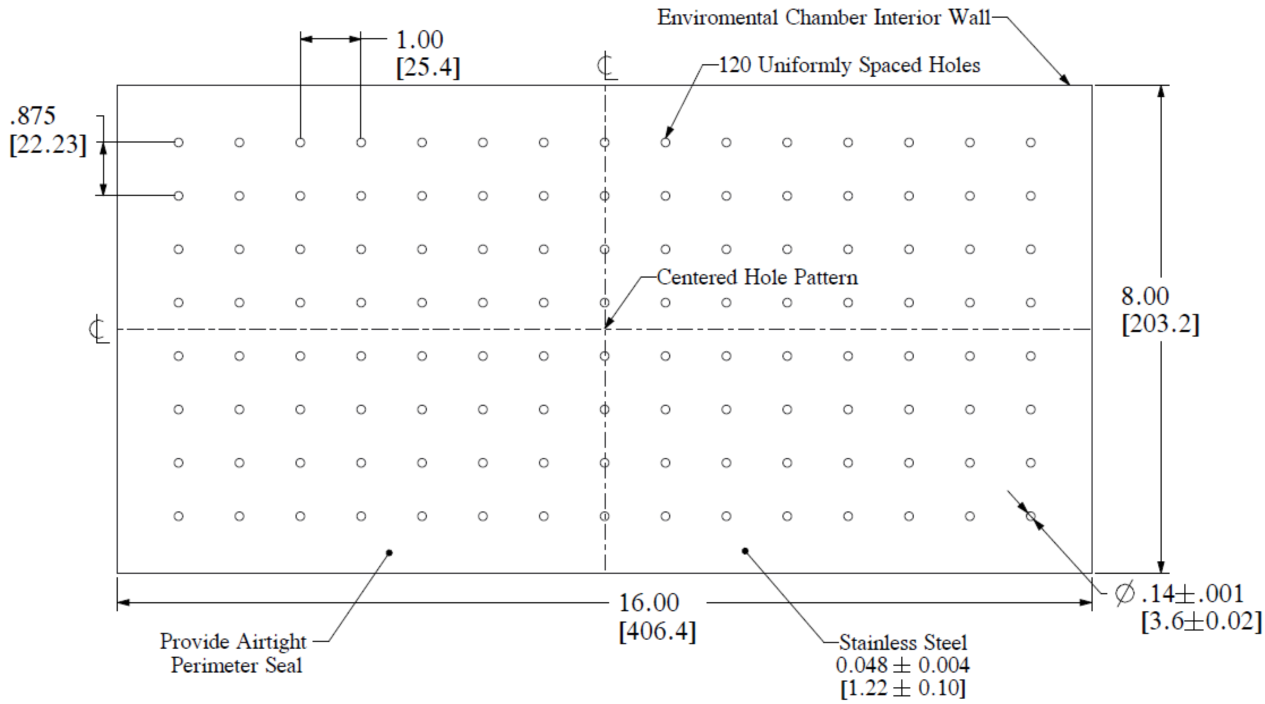


Figure L-21. Dimensioned drawing of the second stage plate

L.1.1.12 Specimen Holder

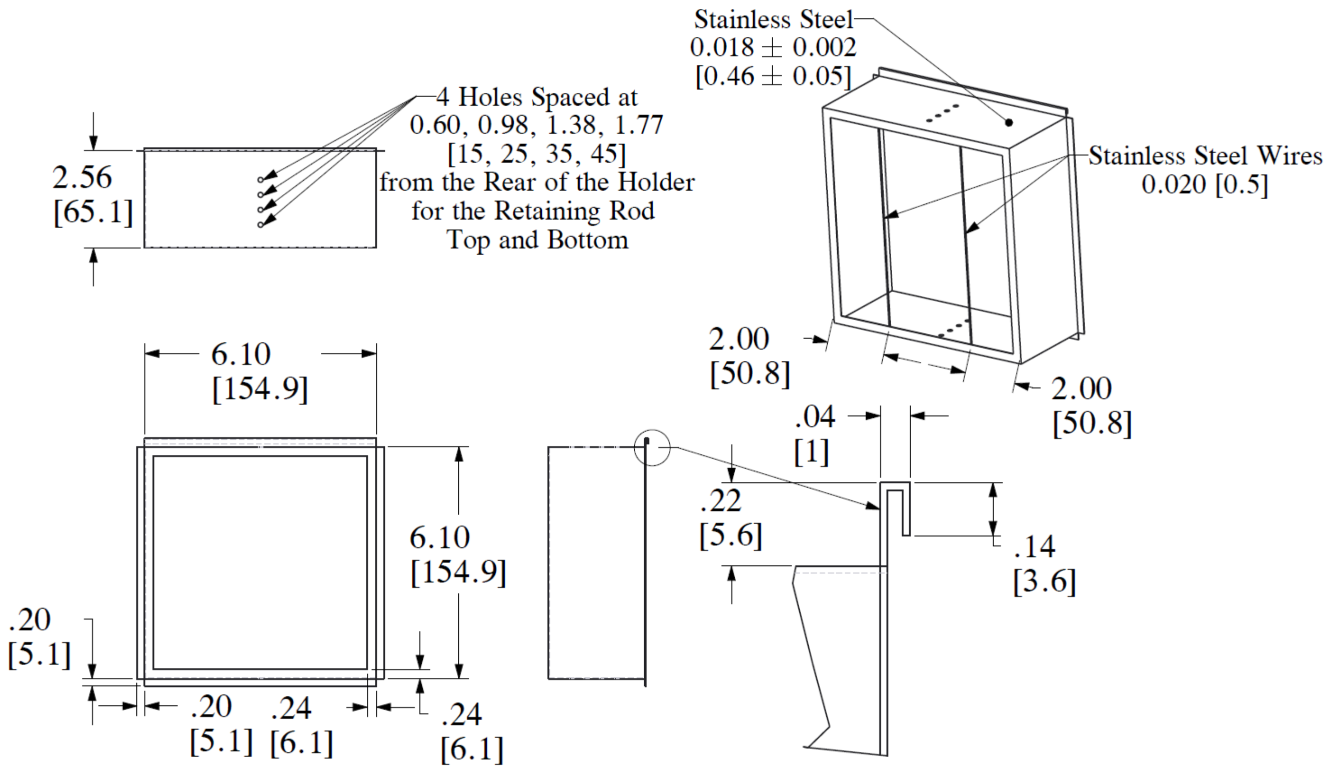


Figure L-22. Dimensioned drawing of the specimen holder

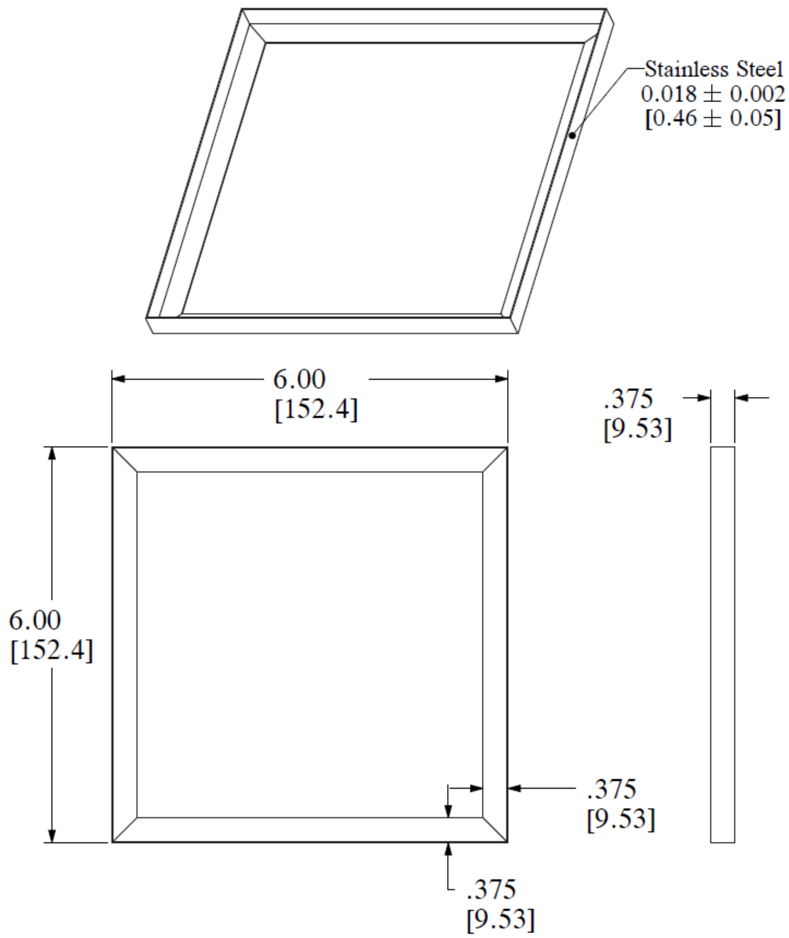


Figure L-23. Dimensioned drawing of the retainer frame

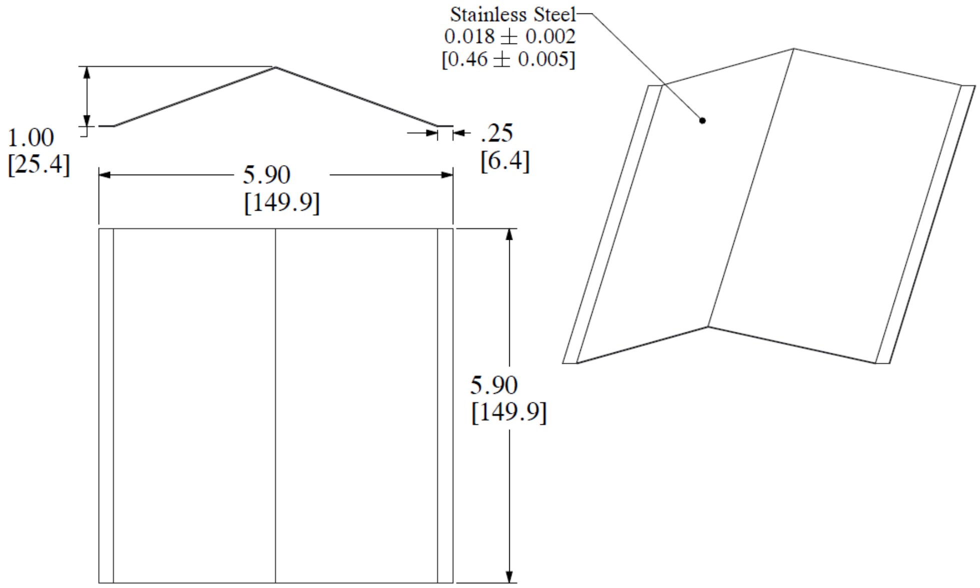


Figure L-24. Dimensioned drawing of the spring

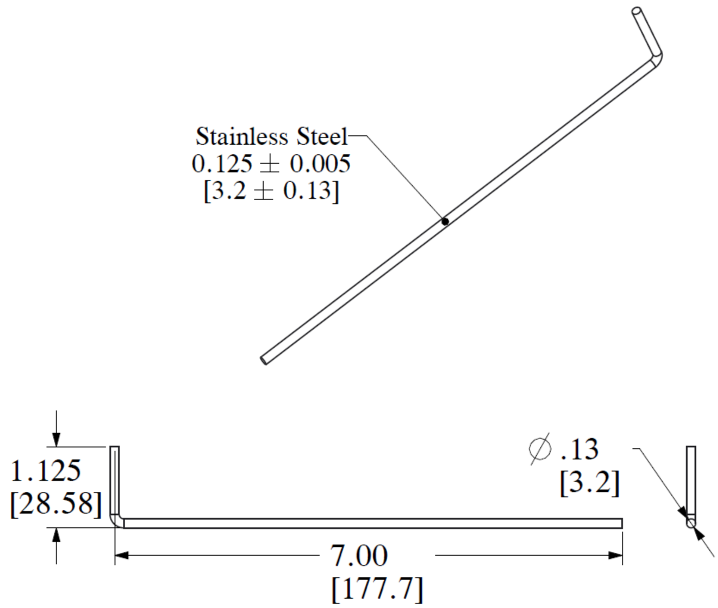


Figure L-25. Dimensioned drawing of the retaining rod

L.1.1.12.1 Drip Pan

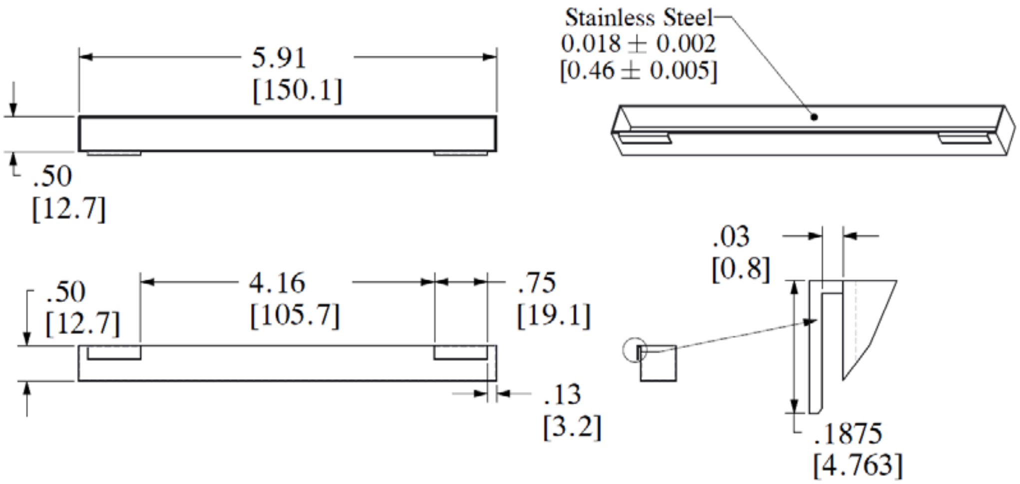


Figure L-26. Dimensioned drawing of the drip pan

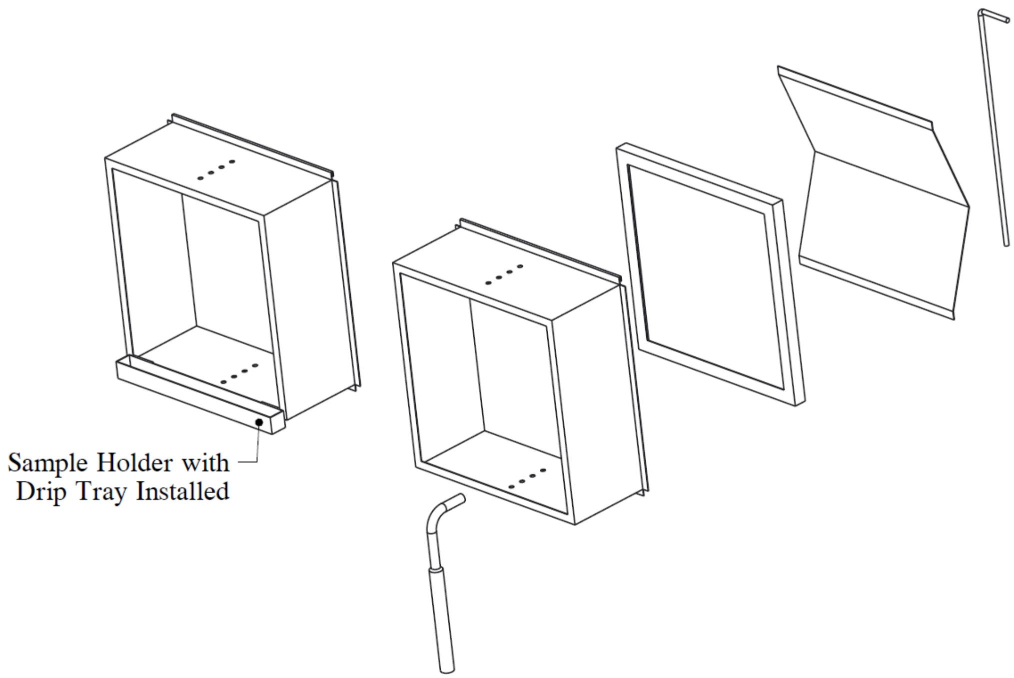


Figure L-27. Exploded view of the sample holder assembly, with and without the drip tray installed

L.1.1.12.2 Holding Chamber/Injection Mechanism

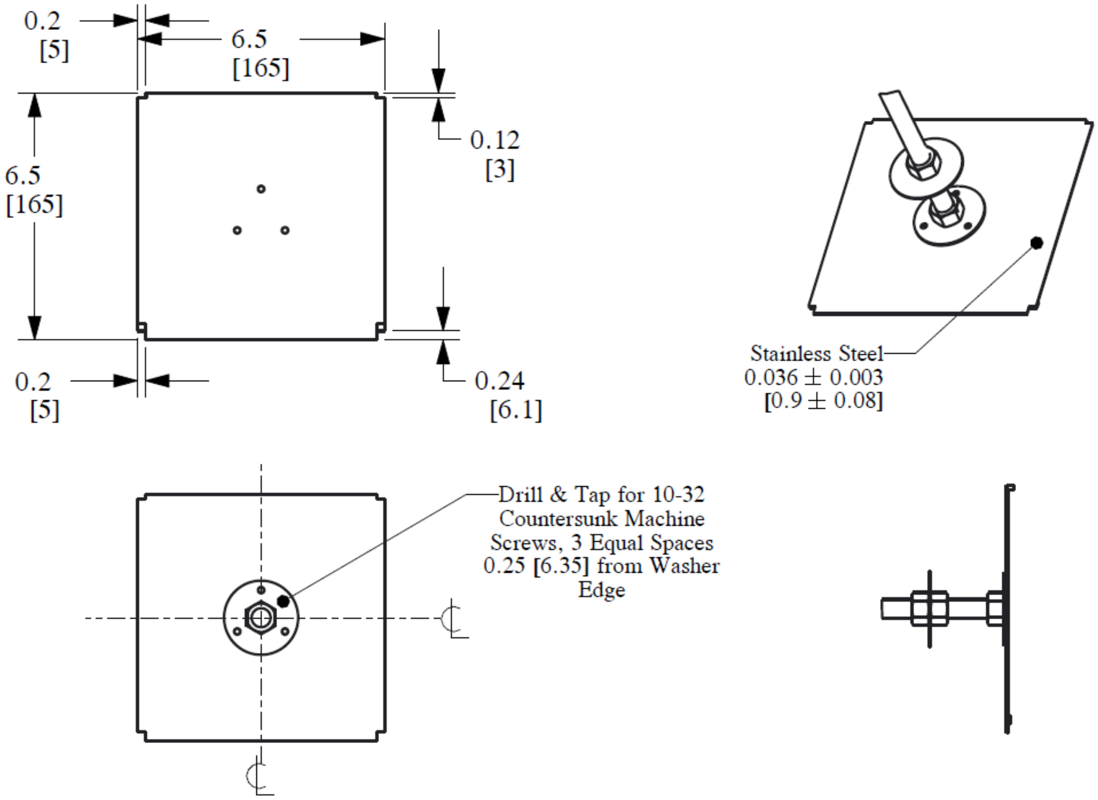


Figure L-28. Dimensioned drawing of the sample holder plate

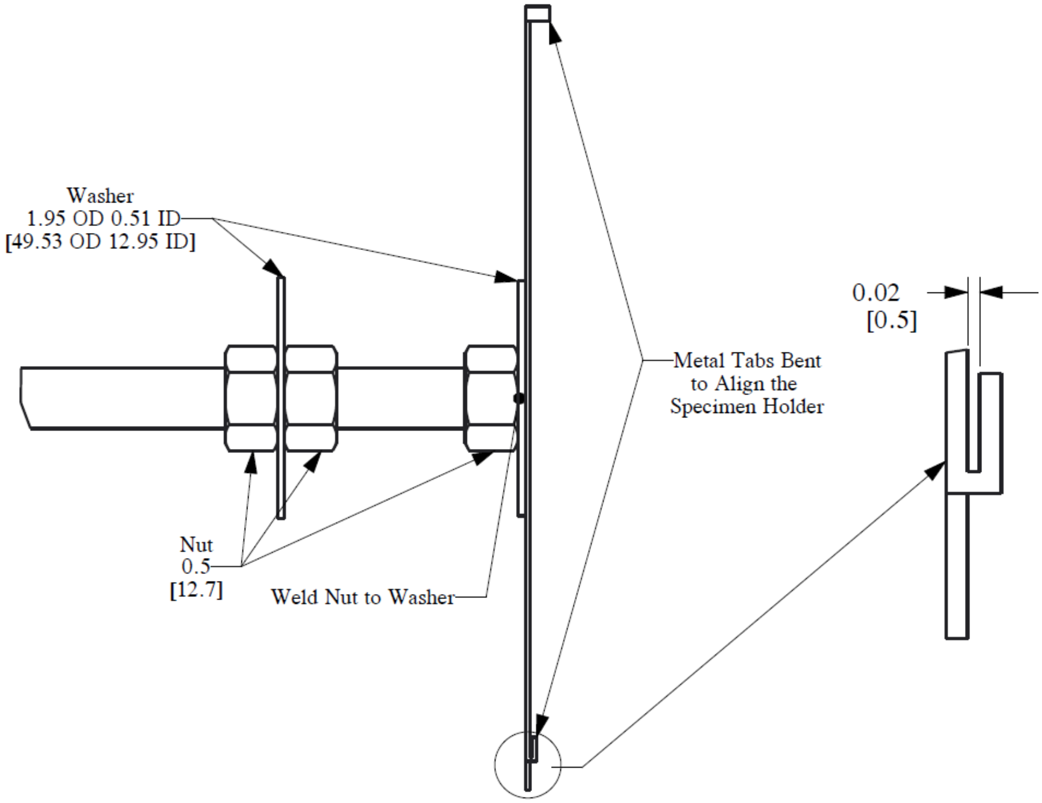


Figure L-29. Detailed view of the sample holder plate

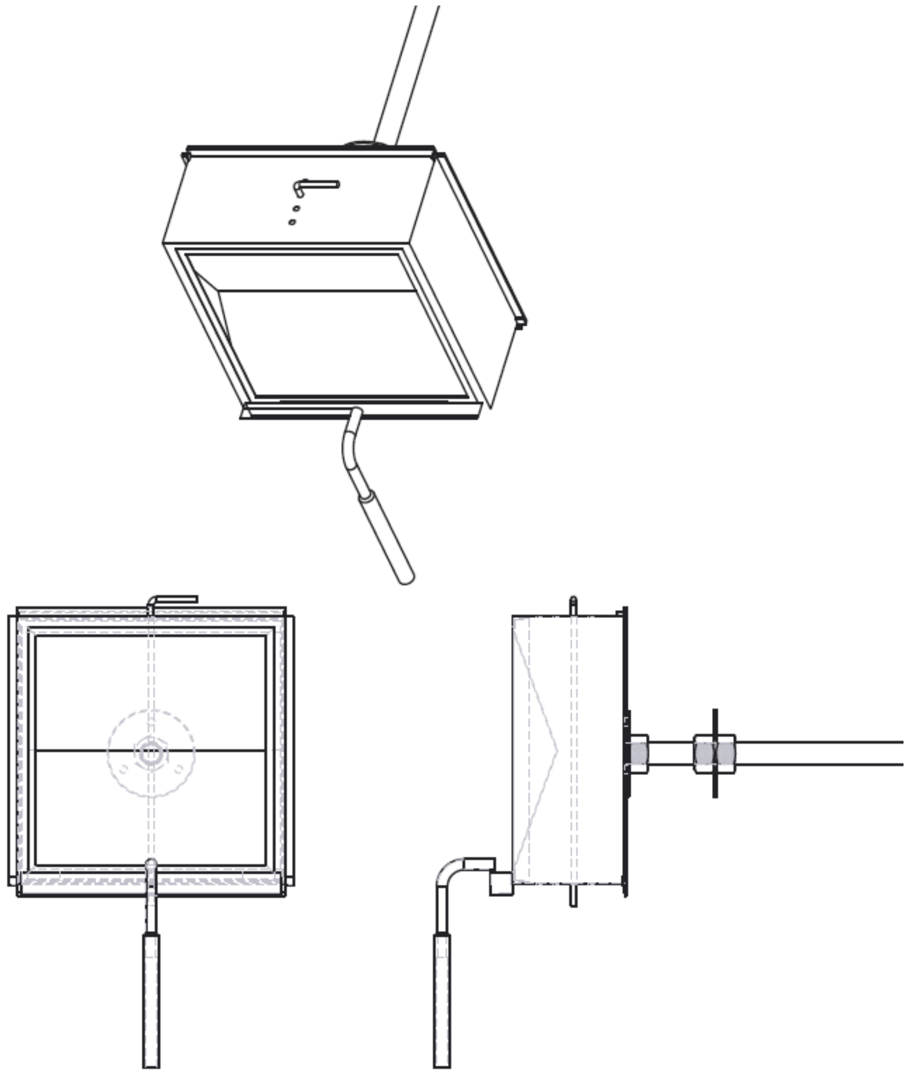


Figure L-30. Views of the sample holder, injection mechanism, and lower pilot burner

L.1.1.1.13 Heat-Flux Sensor

- Marinite I Board 0.5-inch (12.7 mm) thickness or product of similar specification or function has been found suitable.

  BNZ Materials, Inc.

  400 Iron Horse Park

  North Billerica, MA 01862

  Phone: (800) 888-0061/Fax: (978) 663 – 2735

  URL: http://www.bnzmaterials.com/contact-us/

- Schmidt-Boelter Heat Flux Gauge

  Medtherm Corporation

  P.O. Box 412, Huntsville, AL 35804 USA

  Phone: (256) 837-2000/Fax: (256) 837-2001

  Email: MEDTHERM@comcast.net

L.1.1.1.14 Calibration Gas Mass-Flow Controller (MFC: Methane)

- Sierra Instruments Model C100L or product of similar specification or function has been found suitable.

  Part Number: C100L-NR-2-OV1-SV1-PV2-V1-S1-C3

  Typical Accuracy: ± 0.2% of F.S. for 2 to 20% F.S.

  ± 1% of setpoint for 20 to 100% F.S./2 second response time

  Range: 5000 sccm CH_4

  Fittings: 0.25-inch compression

  Seals: Viton

  Sierra Instruments

  5 Harris Court, Building L

  Monterey, CA 93940

  Phone: (831) 373-0200

  www.sierrainstruments.com

  Note: Calibrate at 0°C and 760 mmHg (Torr) reference conditions. Calibrate points 10 percent, 20 percent, 30 percent, and 40 percent or 1, 2, 3, and 4 SLPM.

- Marinite I Board 0.5-inch (12.7 mm) thickness or product of similar specification or function has been found suitable.

  BNZ Materials, Inc.

  400 Iron Horse Park

  North Billerica, MA 01862

Phone: (800) 888-0061/Fax: (978) 663-2735

URL: http://www.bnzmaterials.com/contact-us/

L.1.2 SPECIMEN PREPARATION

- Reynolds Wrap® Heavy Duty Aluminum Foil (23.62 microns or 0.001-inch thickness) or product of similar specification or function has been found suitable.

L.1.3 HEAT RELEASE RATE

Example—For any point in time during test:

$$(\text{Thermopile}_{\circ\text{C}} - \text{Baseline}_{\circ\text{C}}) * \left(\frac{\text{K}_\text{h} \div 1000}{0.02323\ \text{m}^2}\right) \text{kW/m}^2$$

If:

$\text{Baseline}_{\circ\text{C}} = 297$	[Average thermopile temperature reading at baseline (°C)]
$\text{Thermopile}_{\circ\text{C}} = 400$	[Thermopile temperature reading at any point during test (°C)]
$\text{K}_\text{h} = 17$	[Calibration factor (W/°C)]
Sample Area = 0.02323	[Total calculated area of test specimen (m^2)]

Then:

$$\text{Heat Release Rate} = (400 - 297) * \left(\frac{17 \div 1000}{0.02323}\right) \text{kW/m}^2$$

$$= (103) * (0.732)\ \text{kW/m}^2$$

$$= 75.4\ \text{kW/m}^2$$

L.1.4 TOTAL HEAT RELEASE

Example – For a data collection frequency of 1 Hz or 1 scan per second:

$$\frac{\sum_{t=0}^{n-1} (\text{Thermopile}_{\circ\text{C}} - \text{Baseline}_{\circ\text{C}}) * \left(\frac{\text{K}_\text{h} \div 1000}{0.02323\ \text{m}^2}\right)}{\text{x}} \text{kW} \cdot \text{min/m}^2$$

If:

n = 120	[Total number of data collection points in 2 minutes]
t = 0	[Data point collected at 0 seconds]
x = 60	[Total number of data collection points in 1 minute]

$\mathrm{Baseline}_{\circ C} = 297$ [Average thermopile temperature reading at baseline (°C)]

$\mathrm{Thermopile}_{\circ C} = 400$ [Thermopile temperature reading at any point during test (°C)]

$K_h = 17$ [Calibration factor (W/°C)]

Sample Area = 0.02323 [Total calculated area of test specimen (m^2)]

Scan #	Heat Release Rate/60
T = 0	1.26
T = 1	1.26
.	1.26
.	1.26
.	1.26
T = 119	1.26
TOTAL	150.8

Then:

Total Heat Release (After 2 minutes) $= 150.8\ \mathrm{kW \cdot min/m^2}$

L.2. PASS/FAIL REQUIREMENTS USING 80-PERCENT RULE

Table L-3. Number of Samples Required to Pass

Total Samples Tested	Must Pass	%
3	3	100%
4	4	100%
5	4	80%
6	5	83%
7	6	86%
8	7	88%
9	8	89%
10	8	80%
Continued…	Continued…	Continued…

L.2.1 MISCELLANEOUS

- Test Specimens (system checks) - P/N S2221 6-by-6-by-1/8th-inch core panel or product of similar specification or function has been found suitable.

  Schneller, LLC.

  6019 Powdermill Rd.

  Kent, OH 44240

  USA

  Phone: 330-676-7127

  Fax: 330-673-6374

  URL: http://www.schneller.com

- Hole size Go/No-Go drill guide

Table L-4. Drill Size Numbers and Equivalent Diameters

Component	Drill Size		Tolerance (Inches)
	Go Drill	No-Go Drill	
Upper Pilot Burner (15 holes)	# 59	# 58	0.041 ± 0.0005
Second Stage Plate (120 holes)	# 28	# 27	0.140 ± 0.001
Air Distribution Plate (8 holes)	# 4	# 3	0.209 ± 0.001

APPENDIX M—RADIANT HEAT PANEL FLAME-PROPAGATION APPARATUS

M.1. SCOPE

M.1.1 APPLICABILITY

This test apparatus is intended for use in determining the flammability and flame-propagation characteristics of materials when exposed to radiant heat and an open flame.

M.2. DEFINITIONS

M.2.1 IGNITION TIME

Ignition time is the length of time the burner flame is applied to the sample.

M.2.2 ZERO POSITION

Zero position is the pilot burner application point on the test sample, which is level with the top surface of the sliding platform upper flange. The zero position coordinates are centerline (± 0.25 inches) with the sliding platform opening (front to back) and 4.5 ± 0.5 inches (114 ± 13 mm) from the inside right edge of the platform frame.

M.2.3 RADIANT HEAT SOURCE

The radiant heat source is an electric panel having six 3-inch-wide (76.2 mm) emitter strips (see section M.3.2 Electric Radiant Heat Source).

M.3. TEST APPARATUS

M.3.1 TEST CHAMBER

Tests will be conducted in a radiant panel test chamber as shown in figure M-1. The test chamber is 55 ± 1 inches (1397 ± 25.4 mm) wide, 20 ± 1 inches (508 ± 25.4 mm) deep (front to back), and 29 ± 1 inches (737 ± 25.4 mm) high from the top of the sliding platform to the top of the chamber frame. The internal walls and ceiling of the chamber must be insulated with 0.5-inch-thick (12.7 mm), high-temperature insulation refractory board with a maximum thermal conductivity of 0.5 Btu·in/hr·ft^2·°F (0.072W/m·K) at 500°F (260°C) and a minimum density of 15 lb/ft^3 (240 kg/m^3). All chamber dimensions are taken from the inside of these insulated walls.

A thin aesthetic sheathing material, such as 0.060 ± 0.010-inch (1.5 ± 0.3 mm) aluminum, is used to conceal the insulation on the outside of the chamber. The floor area below the sliding platform must remain open.

On the front side, a high-temperature glass viewing window must be installed. The window is 9 ± 3 inches (229 ± 76 mm) high by 48 ± 4 inches (1219 ± 102 mm) long. The sliding platform drawer sits below the viewing window.

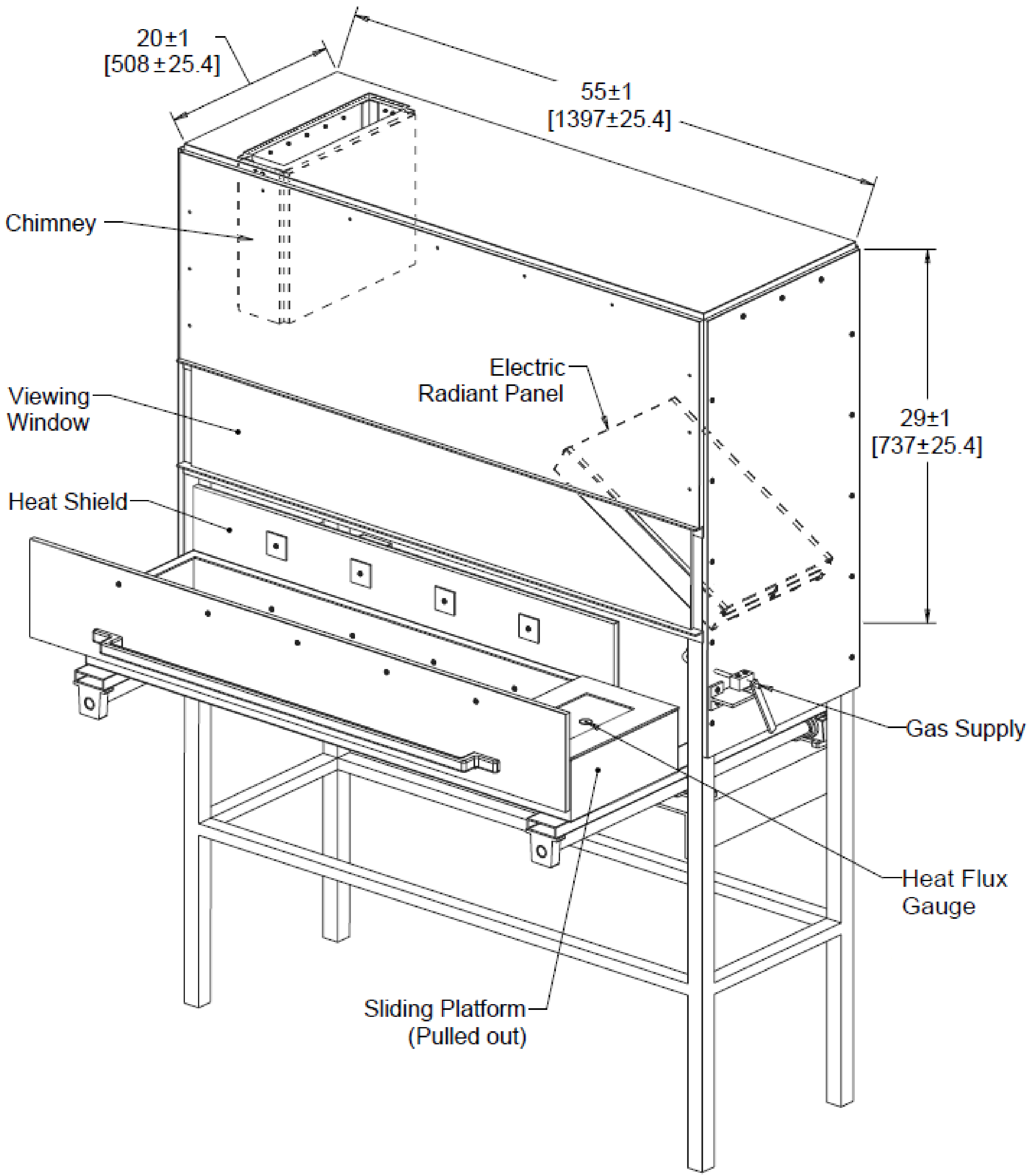


Figure M-1. Test chamber

The chamber must have an internal chimney that extends to and terminates at the top of the chamber. The chimney is placed at the opposite end of the chamber from the radiant heat source. The center point of the chimney is located centerline ± 0.25 inch (± 6 mm) with the chamber (front to back) and 4.75 ± 0.25 inches (121 ± 6 mm) in from the left exterior wall. The interior of the chimney must be lined with high-temperature insulation board. The interior dimensions of the chimney are 4.25 ± 0.25 inches wide (108 ± 6 mm), 15.75 ± 0.5 inches (400 ± 13 mm) deep (front to back), and 13 ± 0.25 inches (330 ± 6.4 mm) high (see figure M-2). Test results can be significantly influenced by the condition of the chimney in the test chamber. The chimney must always be open and clear of obstruction for valid results. The test chamber should be located under an exhaust hood to facilitate clearing exhaust smoke during each test.

Ensure all shiny surfaces inside the chamber, such as the chamber frame, chimney frame, sliding platform, HFG calibration frame assembly, and sample retaining frame, are painted with a high-temperature flat black paint to minimize reflection.

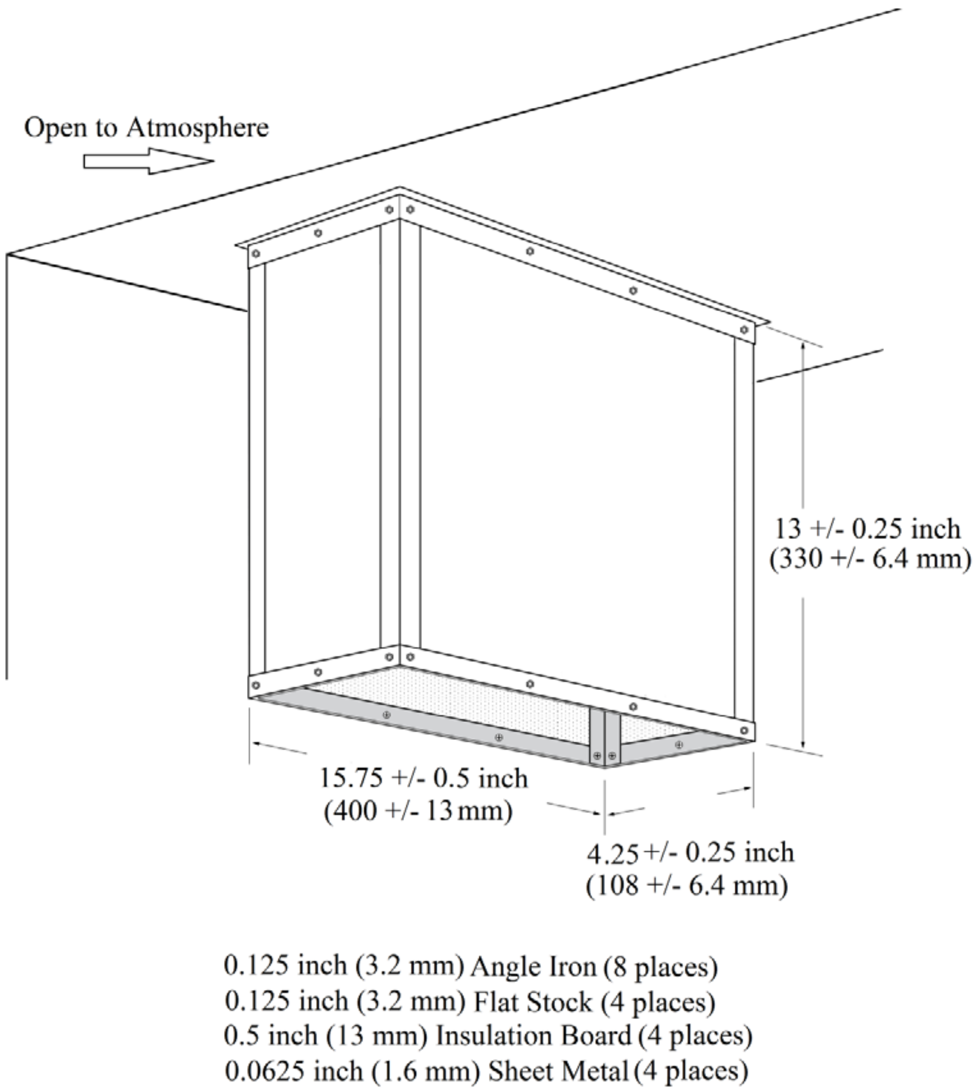


Figure M-2. Interior view of internal chimney

NOTE: The high-temperature insulation board used to line the radiant panel test chamber is the same board used to line the internal chimney. A high-temperature board, such as Superwool Plus® board, is an example of a material suitable for these purposes. Superwool Plus® is manufactured by Morgan Thermal Ceramics in Augusta, Georgia, (706) 796-4200. Their products are also *available through their distributors. It is available in 1-inch, 0.50-inch and 0.25-inch thicknesses.*

M.3.2 ELECTRIC RADIANT HEAT SOURCE

The electric panel must have six, 3-inch wide emitter strips as shown in figure M-3. The emitter strips must be perpendicular to the length of the panel. The panel must have a radiation surface of 12.6 by 18.75 inches (321 by 476 mm) and be capable of operating continuously at the typical temperature range required to maintain the specified heat flux. A solid-state temperature controller and microprocessor-based power controller are used to set the electric panel operating parameters. A solid-state temperature controller and microprocessor-based power controller are used in conjunction with a bayonet-type thermocouple to set the electric panel operating parameters typically within a range of 1100° ± 50°F (593° ± 27°C). Controller set points beyond this range may be indicative of an underlying heat-flux problem, failing electrical panel, or failing/misaligned thermocouple and may require repair or replacement.

NOTE: A suitable 7574-watt electric panel is fabricated by Power Modules Inc. (PMI) of Havertown, PA, 1-800-437-4328. When purchasing a panel, be sure to specify the voltage and frequency (Hz). Its part number is10799-FAA.

NOTE: A solid-state temperature controller and microprocessor-based power controller are used to set the electric panel operating parameters. Acceptable controllers are manufactured by the Watlow Electric Manufacturing Company, (636)-441-5077. They are available at PMI or through a Watlow distributor. The EZ Zone controller is an acceptable controller for this test apparatus. Its part number is PM6C1CA-AAAAAAA.

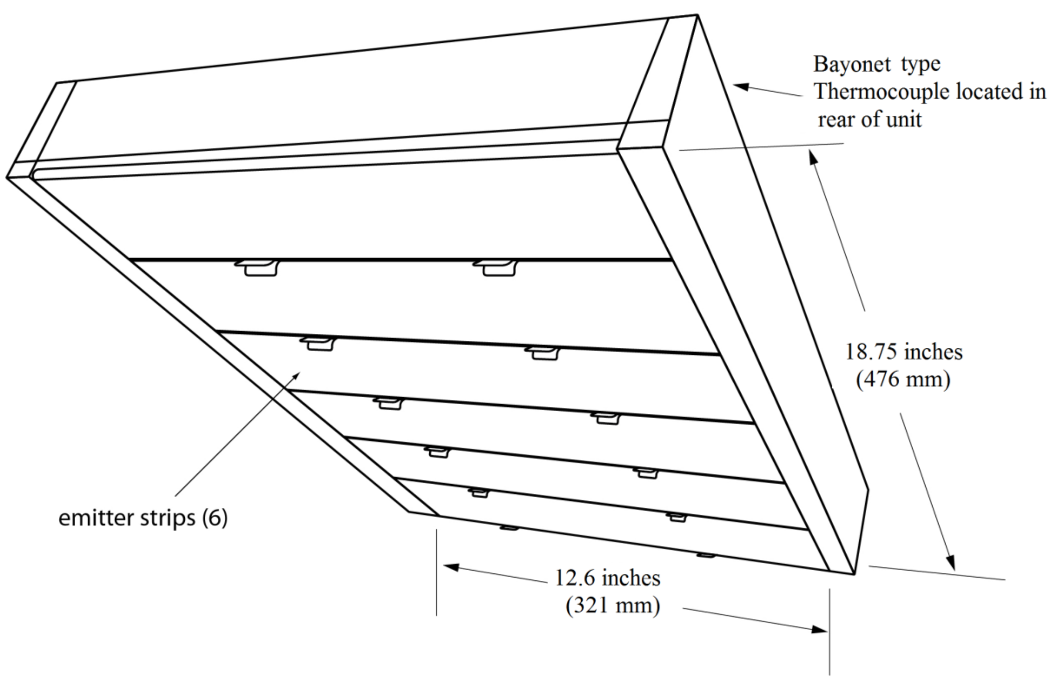


Figure M-3. Electric radiant panel

M.3.3 RADIANT PANEL PLACEMENT

The electric panel must be mounted in the test chamber at 30 ± 1 degree to the horizontal sample plane and 7.5 ± 0.125 inches (191 ± 3 mm) above the zero position. This dimension lines up approximately 0.25 inch (6 mm) below the top edge of the second emitter strip. The longitudinal centerline of the heater and the longitudinal centerline of the sliding platform opening must be in line ± 0.25 inch (± 6 mm). See figure M-4.

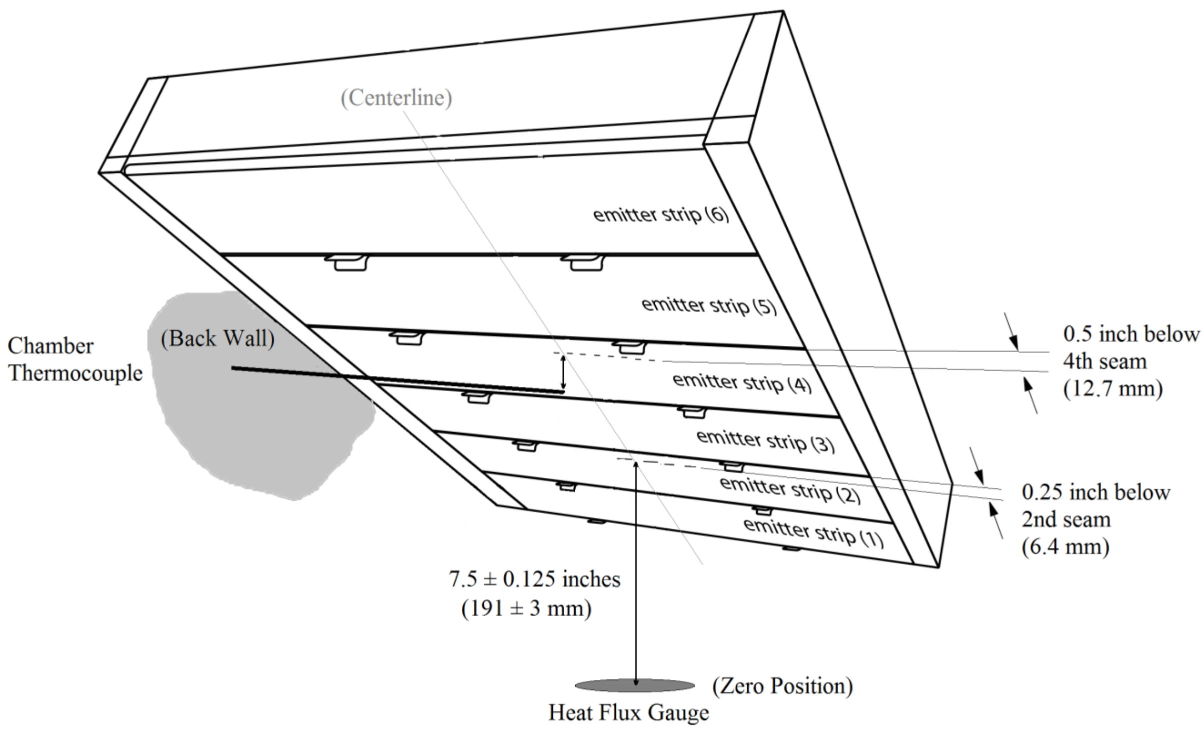


Figure M-4. Electric radiant panel placement

M.3.4 SAMPLE HOLDING SYSTEM

The drawer (also called the sliding platform) serves as the housing for test-sample placement in a fixed and level position. It must be 43.5 to 50.5 inches (1105 to 1280 mm) long by 13.25 ± 0.25 inches (336.5 ± 6.35 mm) wide. However, the recommended length is 50.5 inches (see figure M-5). The drawer must be between 2 inches (51 mm) and 6 inches (152 mm) deep. It may be necessary to use shims/multiple sheets of insulation boards to obtain the correct height for a material to be level with the bottom surface of the sliding platform upper flange. The entire opening on the inside of the drawer must be covered during testing to prevent any convective airflow.

The test sample must be placed on a sheet of high-temperature insulation board that has been preheated to drive off any flammable organic material. For new boards, this can be accomplished by adjusting the setpoint on the power controller to 1085°F (585°C). This temperature setting produces a temperature of approximately 500°F (260°C) at the surface of the board at the zero position. It takes approximately 30 to 40 minutes to reach this temperature and to stabilize. Heat soak the new boards for approximately 1 hour. Once complete, lower the lighted pilot burner into the test position and burn for approximately 2 to 3 minutes.

To help retain heat and protect the test sample from excessive preheating, attach a 0.5-inch thick (12.7 mm) piece of high-temperature board to sheet metal (via screws, washers, and nuts or adhesive) and mount to the back of the platform aligned with the left edge of the drawer. The height or length of this retainer must not impede the sliding platform movement in and out of the test chamber, but must be as large as possible to cover the open space between the top of the drawer and the bottom of the glass viewing window when the drawer is open. An example heat shield is shown in figure M-1. However, if the platform has been fabricated such that the back side of the platform is high enough to prevent excess preheating (or heat loss) when the sliding platform is out, a retainer board is not necessary. A sliding platform having an air gap exceeding 1 inch (25.4 mm) must have this heat shield attached. Air gaps between the frame of the chamber and the sliding platform allow convective airflow through the test chamber and preheats the sample. When testing materials, the drawer must be closed in 3 seconds or less once the sample is ready.

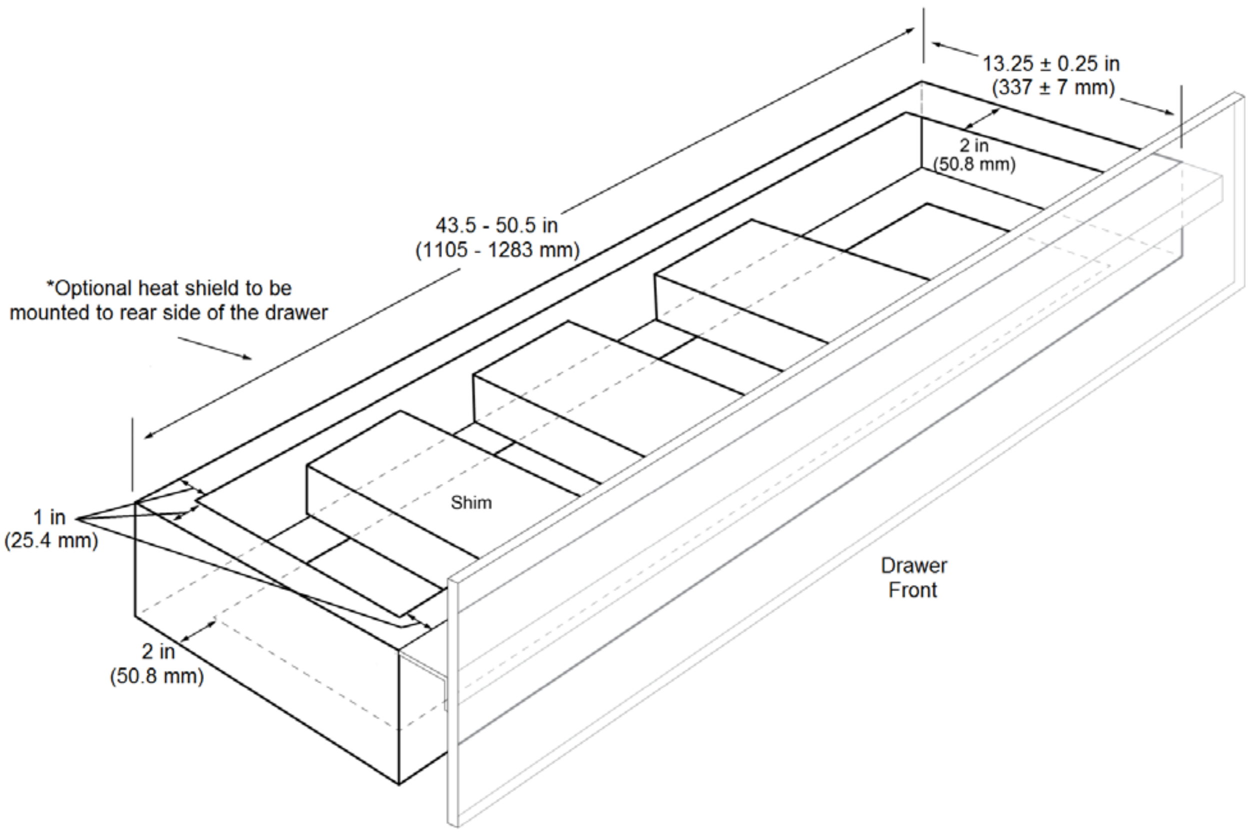


Figure M-5. Sliding platform

M.3.4.1 OPEN AREA AROUND SLIDING PLATFORM

The horizontal area around the sliding platform, between it and the chamber walls, must not be completely sealed off from the outside environment. There must be a minimum 0.25-inch-wide (6 mm) opening on both the left and right sides of the sliding platform, and a minimum opening of 0.5 inch (13 mm) behind the sliding platform, as shown in figure M-6. Certain chamber designs may cover this area with drawer slides and supporting parts, but at minimum, a small area needs to be open to the outside. Tests have shown that a sealed chamber can have an effect on after-flame time and flame propagation length.

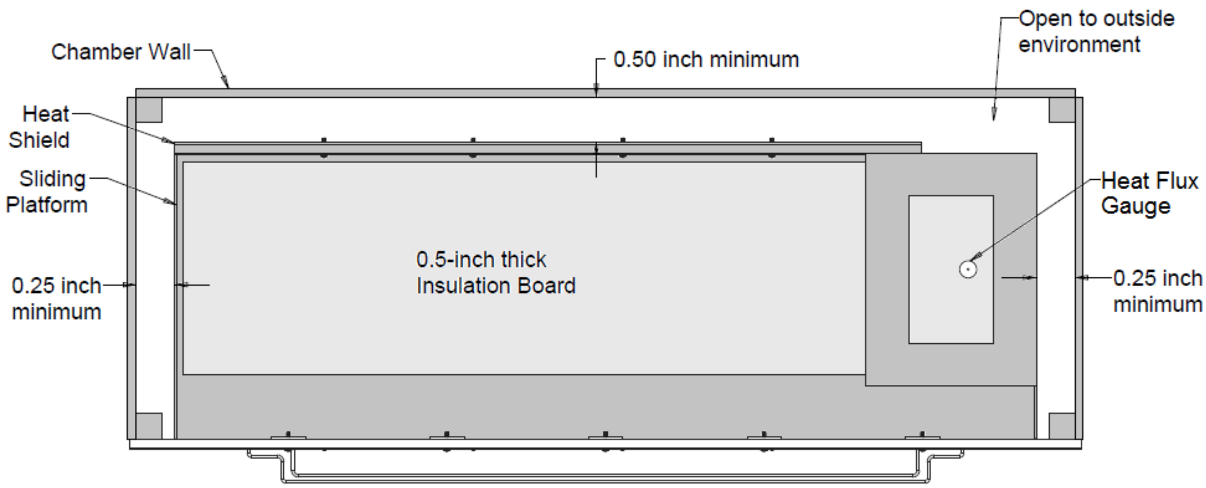


Figure M-6. Open area around the sliding platform

M.3.5 PILOT BURNER

The pilot burner used to ignite the sample must be a commercial propane Venturi torch with an axially symmetric burner tip and a propane supply tube having an orifice diameter of 0.006 inch (0.15 mm) (see figure M-7). The length of the burner tube must be 2.875 inches (73 mm). The propane flow must be adjusted via gas pressure through an inline regulator to produce a blue inner cone length of 0.75 inch (19 mm). A removable 0.75-inch (19 mm) guide (such as a thin strip of metal) may be connected to the top of the burner to aid in setting the flame length. The overall flame length must be approximately 5 inches long (127 mm). An optional high-temperature glass viewing window located on the left wall of the chamber is permitted to ensure proper flame length but must be no larger than 6 by 6 inches (152 by 152 mm).

Provisions must be made to move the burner from the test position such that the flame is horizontal and at least 2 inches (50.8 mm) above the sample plane (standby position). Do not allow the flame to impinge on the radiant panel.

NOTE: Marlin Engineering, located in Bellingham, WA, (360) 671-0155, fabricates an acceptable pilot burner. Its part number is ME1340-K5. They also supply replacement nozzles and extender tubes.

The centerline of the pilot burner must be at a 27 ± 1 degree angle with the sample, 0.5 ± 0.063 inch (12.7 ± 1.6 mm) above the sample and 4.5 ± 0.5 inches (114 ± 13 mm) from the inside right edge of the sliding platform. A stop similar to the one shown in figure M-8 allows the operator to position the burner correctly each time. When testing materials, it must take 1 second or less to lower and raise the pilot burner into position.

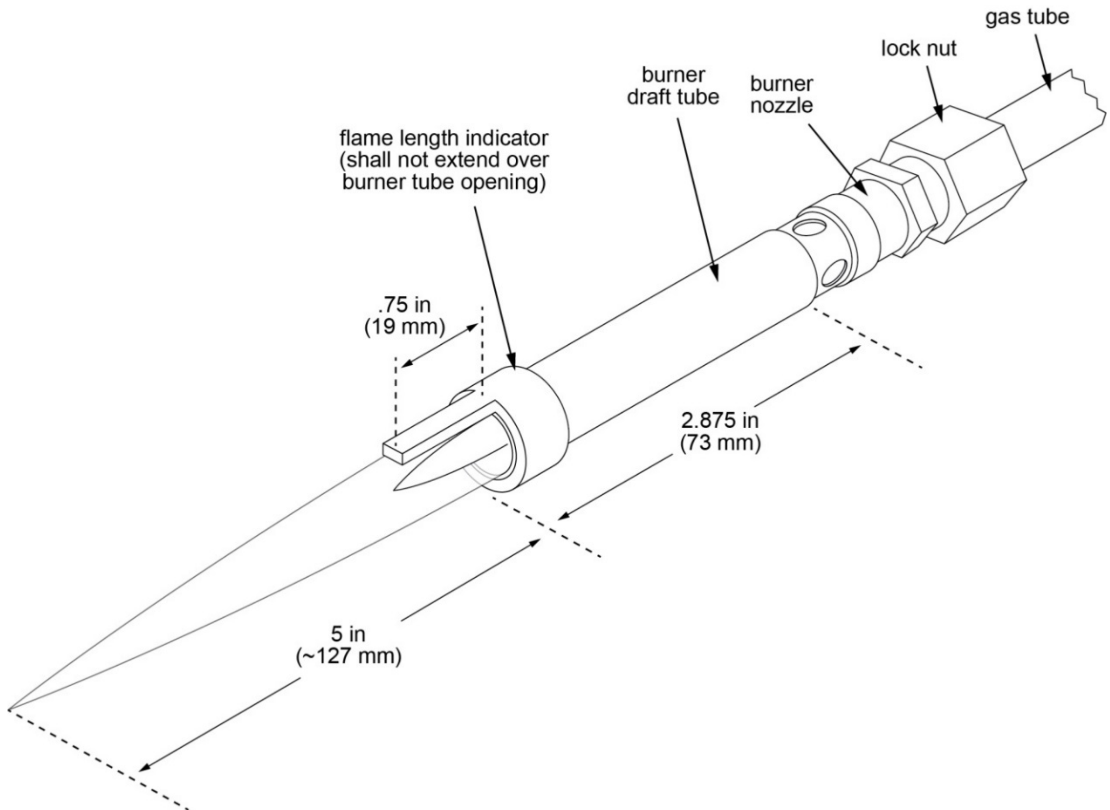


Figure M-7. Propane Venturi torch (pilot burner)

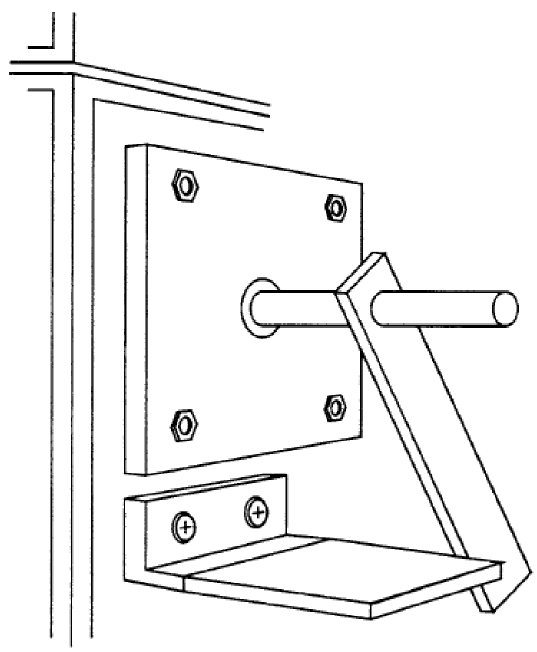


Figure M-8. Propane burner stop

M.3.6 THERMOCOUPLE

Install a 0.0625-inch (1.59 mm) diameter stainless-steel jacketed Type K (chromel-alumel) thermocouple into the chamber through a small hole drilled through the back wall. The thermocouple extends out from the back of the chamber wall positioned centerline ± 0.25 inch (± 6 mm) with the radiant panel, and 2 ± 0.125 inches (51 ± 3 mm) downward vertically, just below the 0.5-inch (12.7 mm) point from the fourth emitter strip seam (see figure M-9).

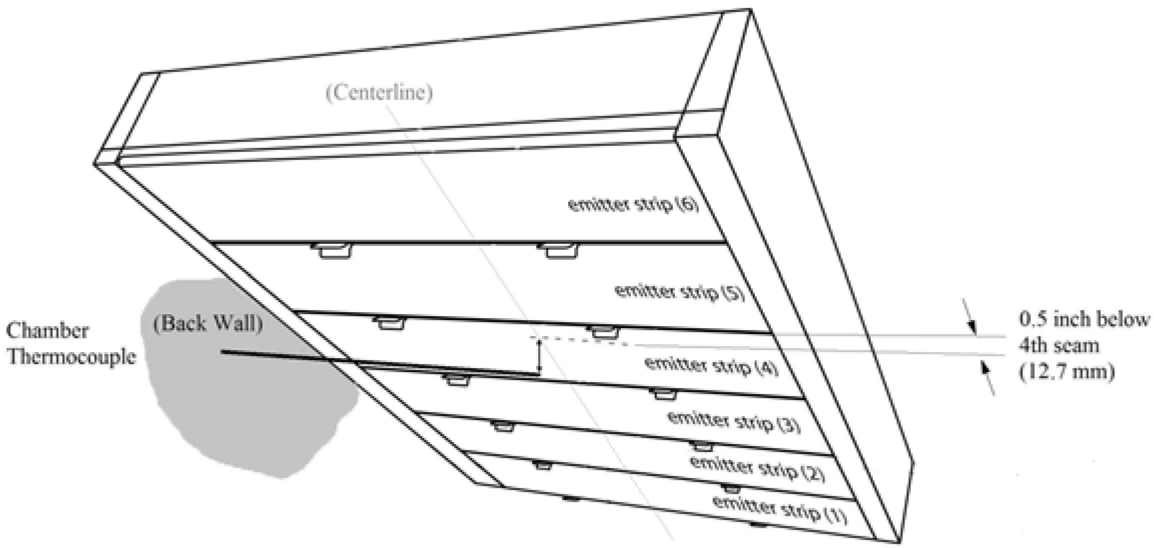


Figure M-9. Thermocouple placement

M.3.7 HEAT-FLUX GAUGE

A water-cooled, Gardon-type heat-flux gauge (HFG), or calorimeter, as specified in appendix H, will be used to determine the total heat-flux at three positions within the chamber. The HFG cooling water temperature, pressure, and flow shall be maintained within the manufacturer's recommendations. Ensure no condensation occurs on the sensor face at any time (often caused by cooling water being too cold).

The HFG must have a thin, full-faced, opaque coating of high-temperature, high-emissivity, ultra-flat black paint. The sensitivity of the gauge is a function of the surface condition. Changes in the coating may cause drift in the overall characteristic of the gauge. Regularly inspect the measuring surface for physical damage or dust particles that may have accumulated. To maintain accuracy, the measuring surface shall be recoated at regular intervals, followed by recalibration (see appendix H).

NOTE: One currently used HFG (Gardon gauge) is manufactured by the Vattell Corporation, Christiansburg, VA, (540) 961-3576. The part number is TG 1000-1B. Medtherm, located in Huntsville, Alabama (256) 837-2000, also manufactures an acceptable heat-flux Gardon gauge. The Part Number (PN) is 64-5-18 for a plain body with no mounting flange, and PN 64-5-20 is a plain body with a mounting flange.

M.3.8 HFG CALIBRATION FIXTURE

The center of a HFG must be mounted in the zero position as defined in M.2.2 to determine total heat-flux on test samples. The HFG must be mounted in a supporting device protruding through 0.5-inch–thick (12.7 mm) rigid refractory board. The HFG has a 180-degree field of view; therefore, the surface must be mounted flush with the insulation board and not recessed. No portion of the fixture frame assembly can be within 1.25 inch (32 mm) of the HFG. The center of the HFG must be 1.532 inches away from the bottom edge of the pilot burner when it is in the down position. This measurement is to be made with the flame guide removed (see figure M-10).

Alignment features may be added to help secure the fixture in the correct position. The holder must be constructed such that it can be easily moved from one position to the next when conducting a three-position check (see section M.4.2 Three-Position Check).

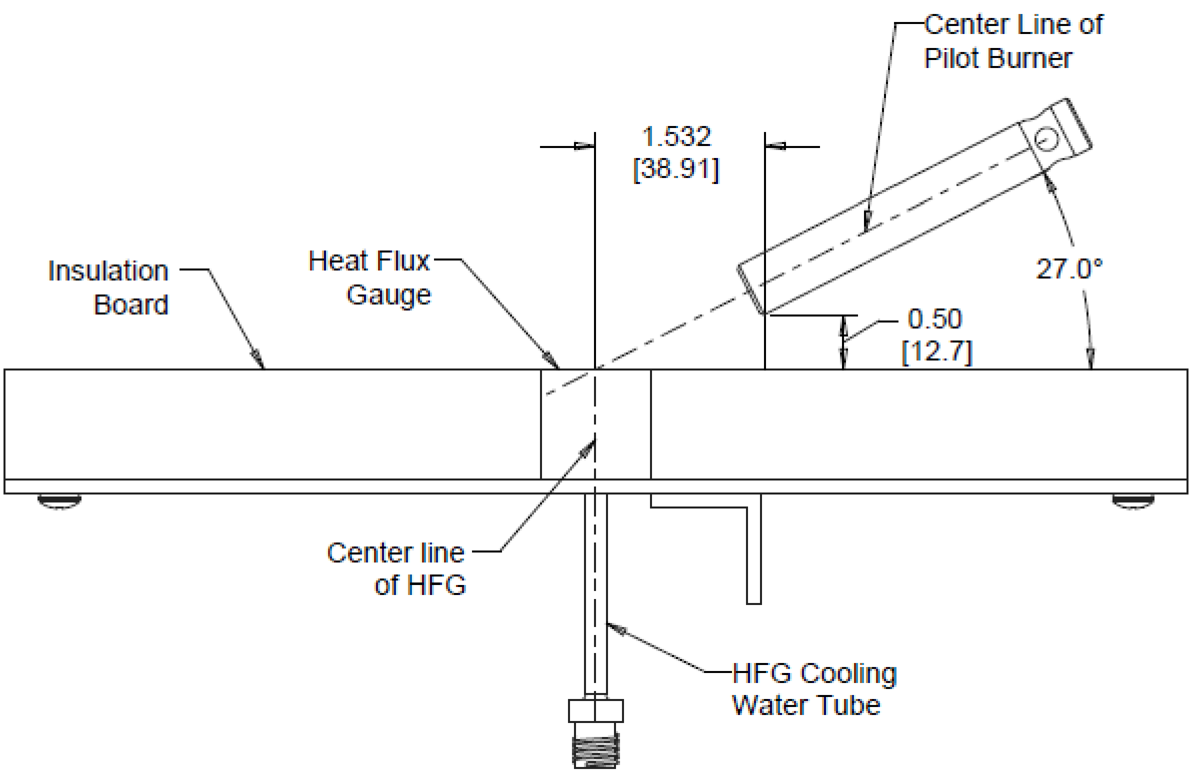


Figure M-10. HFG/Pilot burner alignment (side view)

Note: It is acceptable for the HFG fixture to accommodate up to a 1inch-thick (25.4 mm) piece of high-temperature refractory material.

M.3.8.1 HFG Holder With One Hole

This example HFG fixture is 13.25 inches (336.5 mm) deep, front to back, 10 inches wide (254 mm), and must rest on the top of the sliding platform (see figure M-11). It is fabricated of 0.125-inch (3.2 mm) flat stock steel and has an opening that accommodates a 0.5-inch-thick (12.7 mm) piece of high-temperature refractory material. The exposed board measures 8.25 inches (209.6 mm) front to back and 5 inches (127 mm) across. The board must have a

1.0625 (± 0.0625 inches) (27 ± 1.59 mm) diameter hole drilled through for HFG insertion. The holder must be constructed such that it can be easily moved from one position to the next when conducting a three-position check.

NOTE: The dimensions of the HFG holder are not critical. However, the holder must be constructed such that it can be easily moved from one position to the next, and the hole for the HFG must be dimensionally correct.

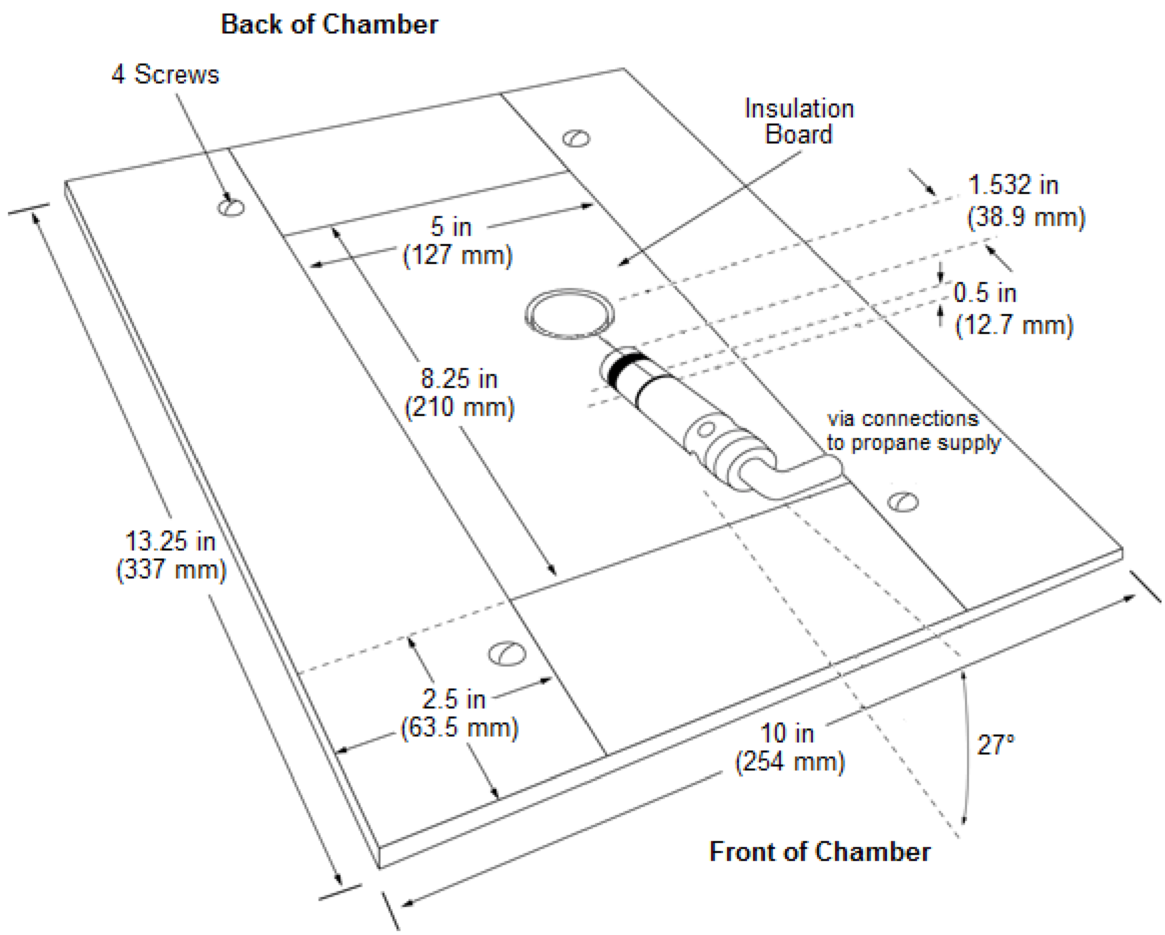


Figure M-11. HFG holder with one hole

M.4. INSTRUMENTATION

M.4.1 DATA ACQUISITION

A computerized data-acquisition system or calibrated recording device with an appropriate range shall be used to record the output of the HFG and the thermocouple. The data system must be capable of recording the HFG output every second during calibration and calculate a 5-minute average of the data. An acceptable data-acquisition system is a 22-bit, analogue-to-digital converter with an accuracy of 0.02 percent of the reading. If a voltmeter is used, it requires a resolution of 0.01 mV and an accuracy of 0.3 percent.

M.4.2 TIMING DEVICE

A stopwatch or other device, accurate to ± 1 second per 8 hours (± 3 sec/day) must be used to measure the time of flame application. It is acceptable to use an automatic timer for moving the pilot burner in and out of test position.

APPENDIX N—VERTICAL FLAME PROPAGATION TEST APPARATUS

N.1. SCOPE

This chapter describes in detail the FAA Vertical Flame Propagation (VFP) test apparatus. All dimensions, unless otherwise stated, are in inches.

N.2. DESCRIPTION

The VFP test apparatus is intended to be used to determine the propensity of materials to propagate flames. An electric coil radiant heat furnace is mounted vertically and opposite to the test sample, a 6- by 12-inch coupon. A propane/air or methane/air ribbon burner impinges on the lower portion of the test sample, initiating material combustion, while the sample is continuously exposed to the radiant heat flux from the furnace. The pilot flame is translated away from the test sample at a predetermined time, and the test is allowed to continue until all material combustion has ceased. The sample is removed from the test frame, and a posttest burn-length measurement is made. The burn length is the only parameter used to determine passing or failing. A general view of the test chamber is displayed in figure N-1.

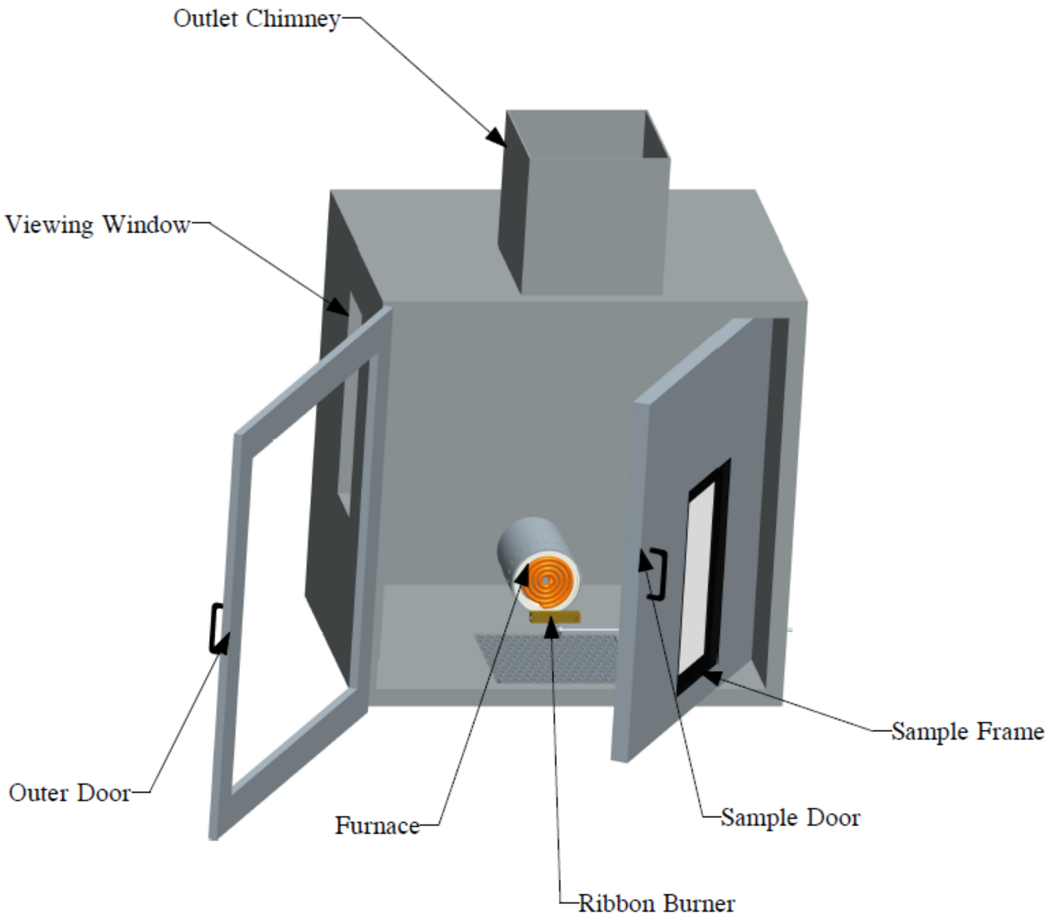


Figure N-1. Schematic of the VFP test apparatus

N.3. TEST APPARATUS COMPONENTS

N.3.1 TEST CHAMBER

The inside dimensions of the box are 22 inches wide, 22 inches high, and 17 inches deep, when observing the front view. Four threaded rods connected to leveling feet are used to adjust the height of the apparatus. There are two doors in the VFP apparatus; an internal and external. A hinge is mounted on the right hand inner wall and a stopper is mounted on the left hand inner wall to hold a door for access to the internal components. The internal door holds the sample frame and, when closed, is mounted to be centered at the exhaust. The external door encloses the system. There are three viewing windows on the unit, one on each sidewall that does not include the sample door.

N.3.2 EXHAUST AND INLET

The chamber exhaust is constructed from 0.0625-inch thickness steel sheet metal on the inner wall of the chamber (figure N-2). The exhaust outer dimensions are 8 inches long, 8 inches wide, and 8 inches tall. This is placed as an outlet for the smoke and gasses to escape from the inner chamber.

On the floor of the unit directly lined up with the location of the exhaust, the air inlet will also be 8 inches long and 8 inches wide. The air inlet has a honeycomb base and perforated stainless-steel sheet on top of it to direct the airflow through the unit evenly.

The aluminum honeycomb is ¾ ± 0.008 inch thick with a ½ inch cell size.

The perforated stainless-steel sheet that rests on top of the honeycomb is 0.024 inch thick, 24 gauge, has a 0.045-inch hole diameter, 37 percent open area, and 0.066 inches hole center to center.

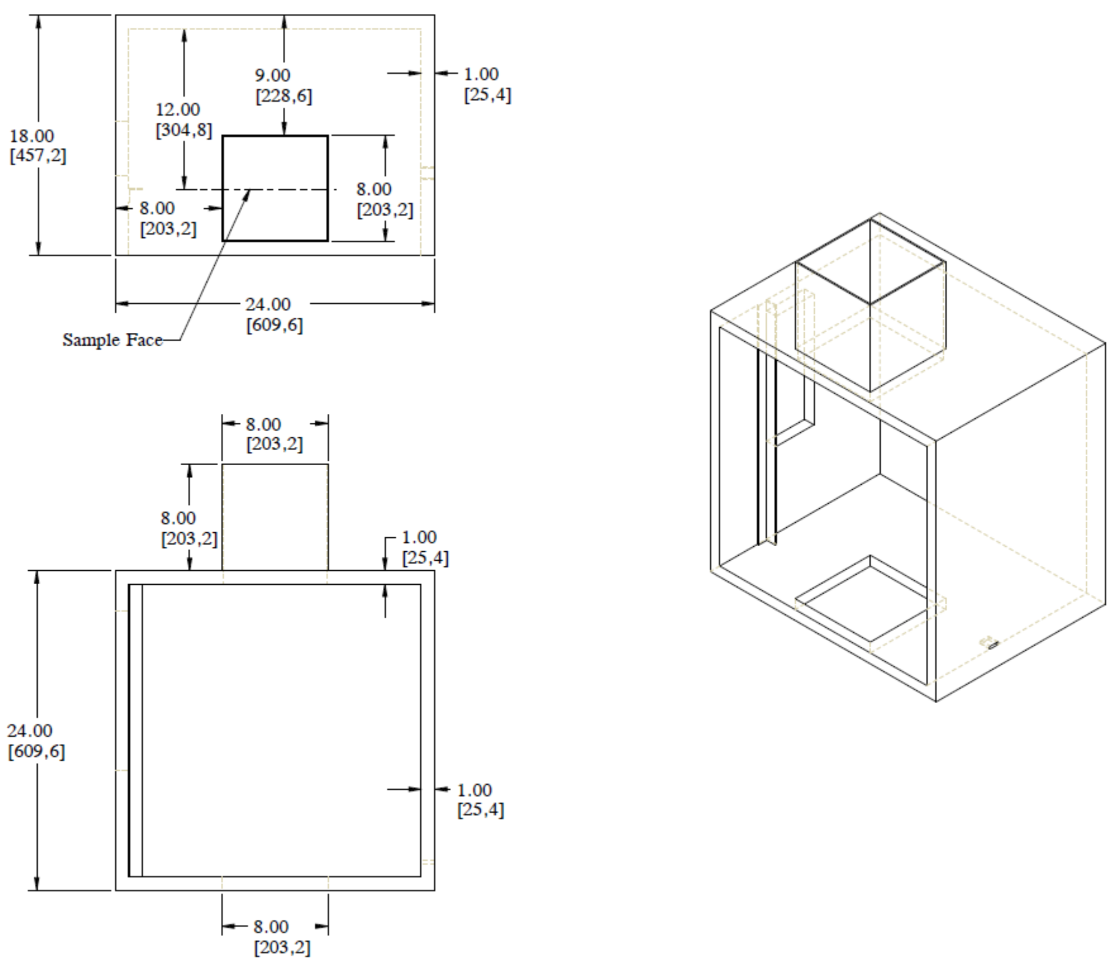


Figure N-2. Dimensioned drawing of the chamber frame

N.3.3 SAMPLE DOOR

The inner sample door is displayed in figure N-3. A metallic tab is attached to the inside top rail of the door to make contact with a magnet mounted on the chamber frame. This ensures the door remains closed during calibration and testing.

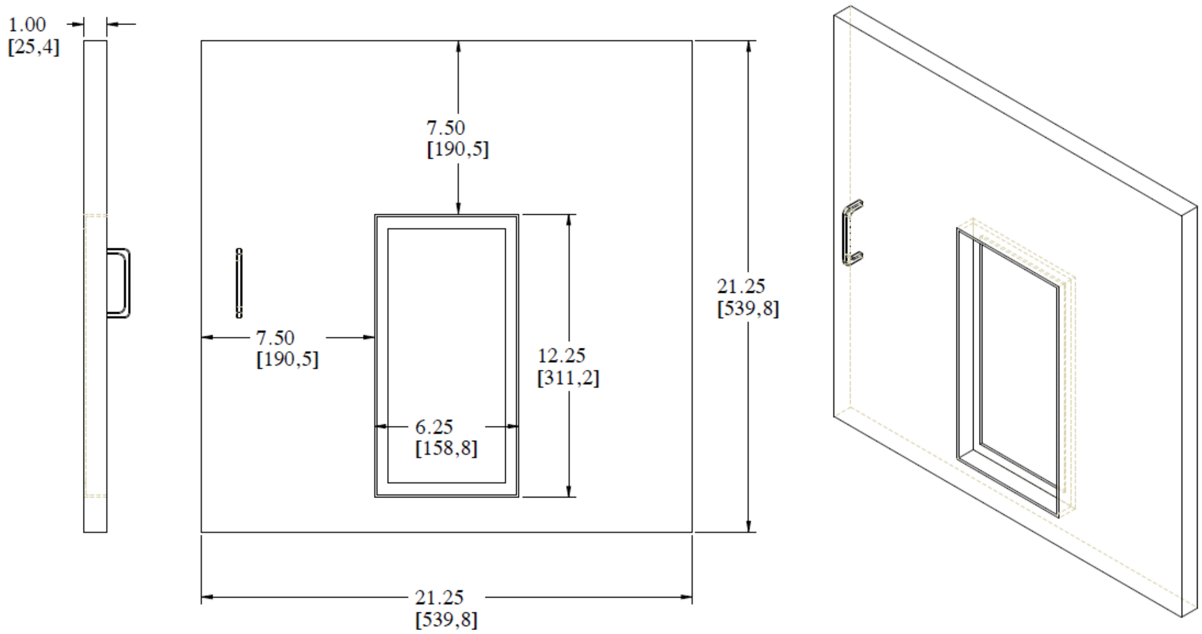


Figure N-3. Dimensioned drawing of the sample door

N.3.4 OUTER DOOR

An outer door encloses the unit and protects the user during testing. This is shown in figure N-4. It has a 2-inch-wide frame with a sturdy glass embedded inside to view the sample door while testing.

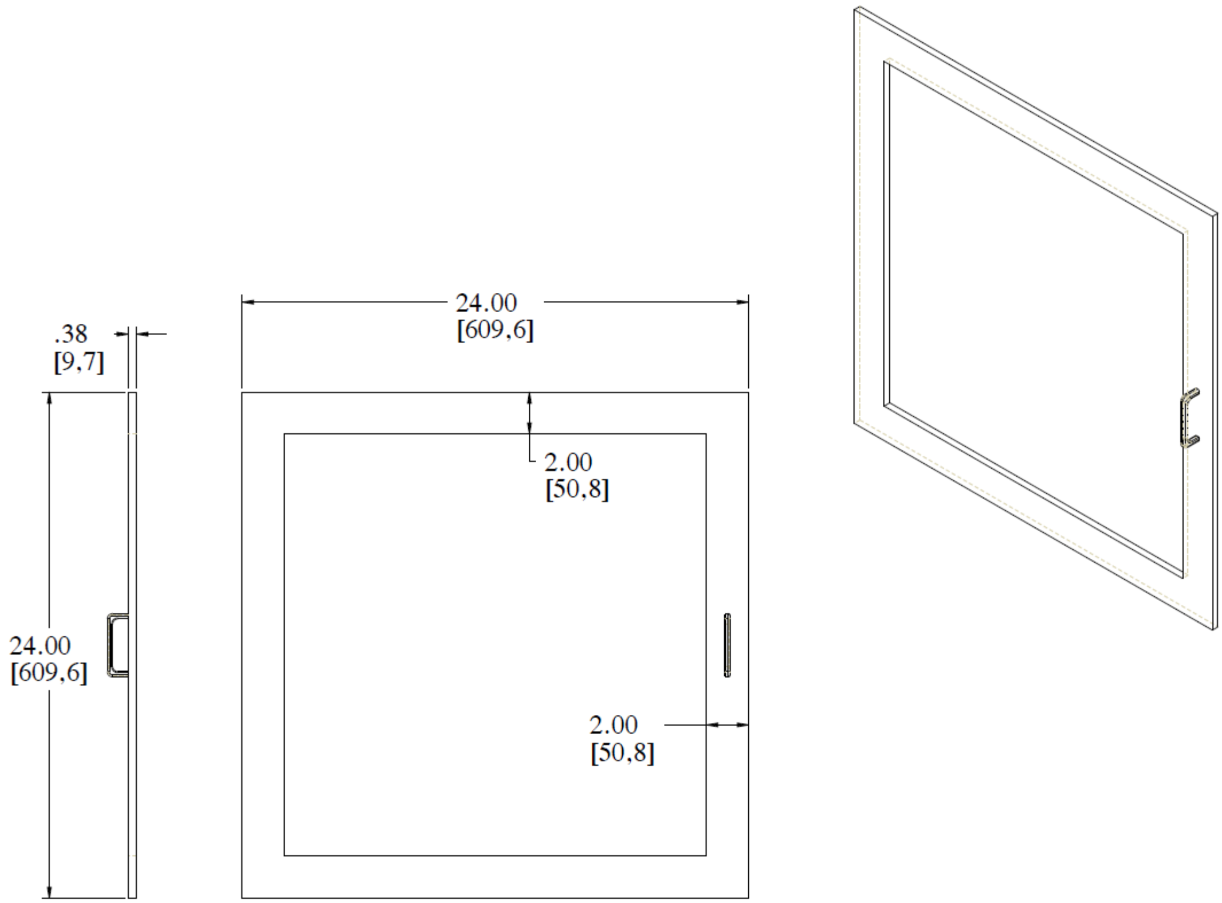


Figure N-4. Dimensioned drawing of the outer chamber door

N.3.5 THERMOCOUPLE

A surface mounted Type K thermocouple, no larger than 24 gauge, is placed on the center of the inner back wall of the test chamber. This is done to measure the internal chamber temperature.

N.3.6 SAMPLE TRAY

The sample tray is displayed in figure N-5. It is constructed from 0.125-inch-thick, 1-inch angle steel. The front facing opening is enlarged by cutting the angle steel down to 0.625 inch to allow for a larger exposed sample surface area. The inside of the sample frame at the right angle is grinded down to make a less rounded angle, which allows for the sample face to lie flush against the inside of the sample frame. This is done to prevent restriction of the sample. A tab is welded to the bottom of the front face to allow for mounting to the sample door. A tab or locking mechanism needs to be placed on the inner sample door to hold the sample tray upright for testing. The tab or locking mechanism will hold the test sample in place and release it when testing is complete.

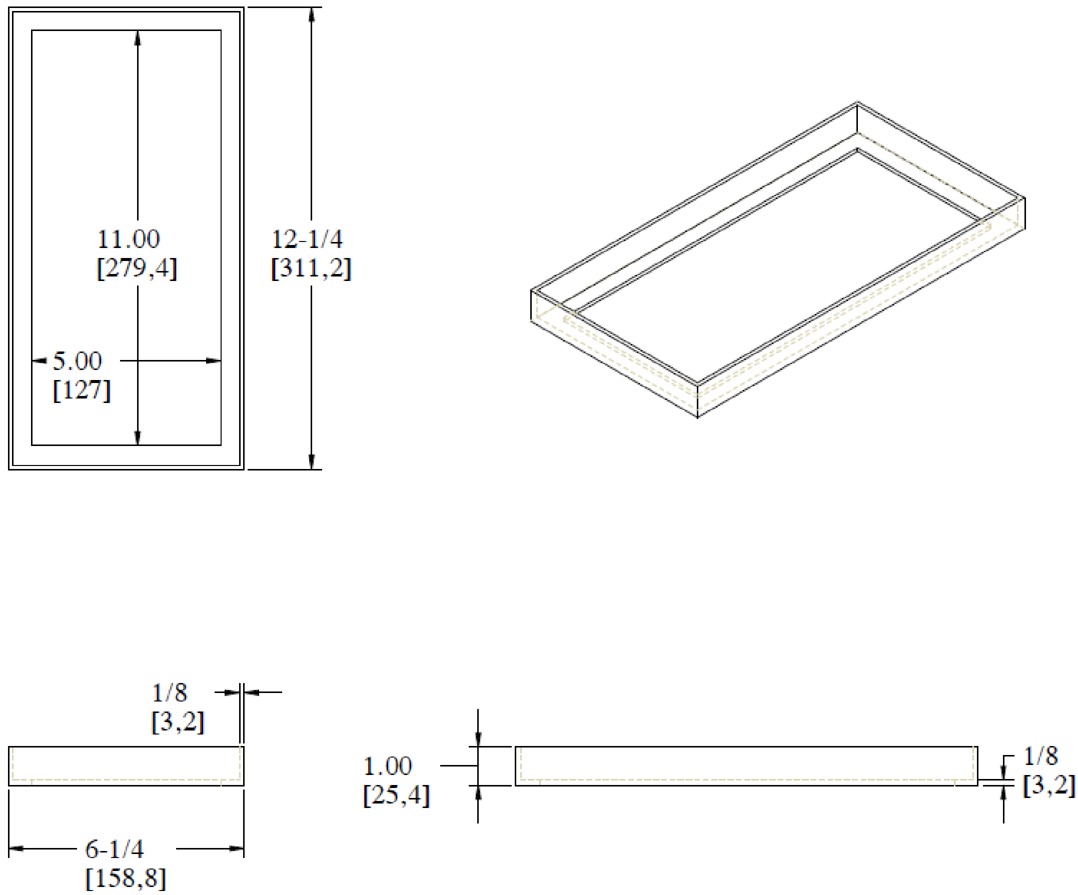


Figure N-5. Dimensioned drawing of the sample tray

N.3.7 SAMPLE RETAINING FRAME

The sample retaining frame is displayed in figure N-6. It is constructed from 0.125-inch-thick steel. It is placed behind the test sample during a test to provide uniform pressure on the back of the sample.

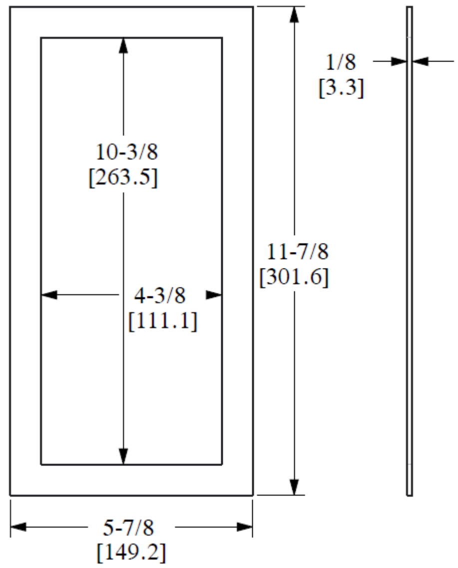


Figure N-6. Dimensioned drawing of the sample retaining frame

N.3.8 CERAMIC FIBERBOARD BLANK PANEL

A diagram of the ceramic fiberboard blank panel is displayed in figure N-7. This is placed inside the sample tray only to reduce heat loss during warmup and between tests.

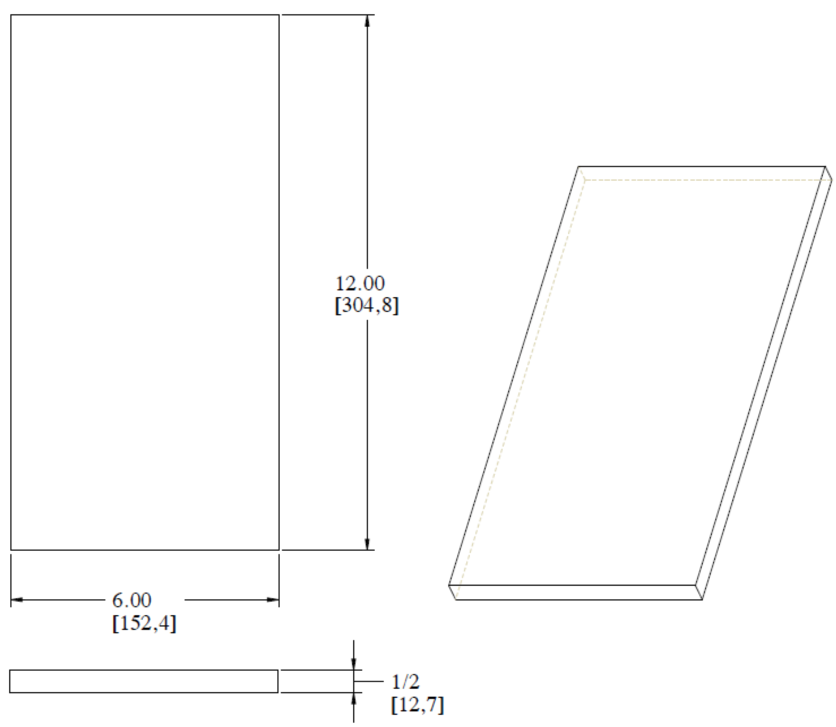


Figure N-7. Dimensioned drawing of ceramic fiberboard blank panel

N.3.9 RADIANT FURNACE

The radiant furnace is displayed in figure N-8. It is the same furnace specified in the smoke-density test called out in 14CFR part 25, appendix F part V, and the evacuation slide test called out in TSO C69c. A spiral tubular heating element with a 0.260-inch Inconel sheath diameter is the heat source. The diameter of the spiral element is nominally 3 inches. It is an 875-watt, 120-volt alternating current (AC) element with an internal resistance of approximately 17 ohms. The front half of the furnace housing is constructed from rolled sheet metal with an outer diameter of 4 inches and inside diameter of 3.9375 inches. The back half has an OD of 3.875 inches and an inside diameter of 3.8125 inches. The face of the furnace coil is recessed 0.0625 inch from the edge of the front housing. Ceramic insulating rings are placed inside the housing to fill the space between the heating coil and the housing.

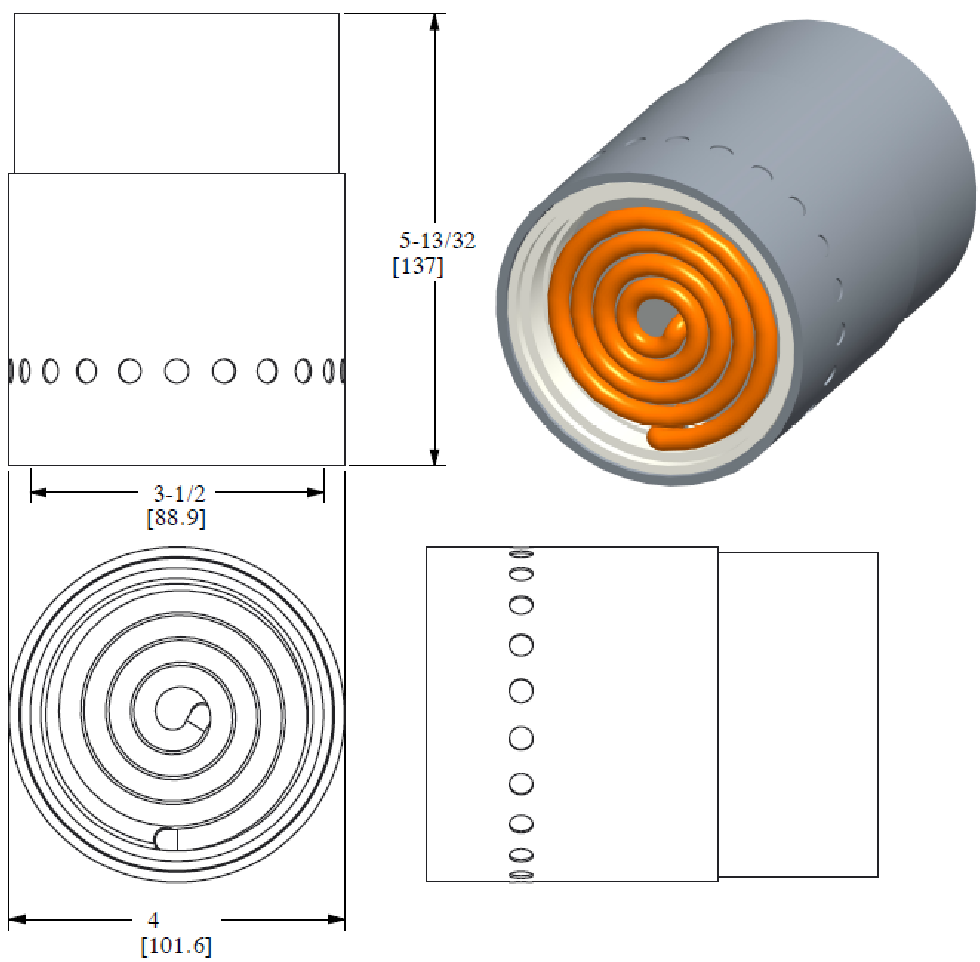


Figure N-8. Dimensioned drawing of the radiant furnace

N.3.10 FURNACE MOUNTING ASSEMBLY

The furnace mounting assembly is displayed in figure N-9. The heights of the furnace and the burner flame are relative to the bottom inner surface of the sample frame, the point where the bottom edge of the test sample would be located. The centerline of the furnace coil is positioned

1.5625 inches (39.6 mm) above the bottom of the sample frame. The centerline of the ribbon burner face is positioned 1.125 inches (28.7 mm) above the bottom of the sample frame. The furnace distance is measured relative to the inner vertical surface of the sample frame, where the plane of the test-sample surface would be located. The distance of the furnace coil from the inner vertical edge of the sample frame is 3 inches.

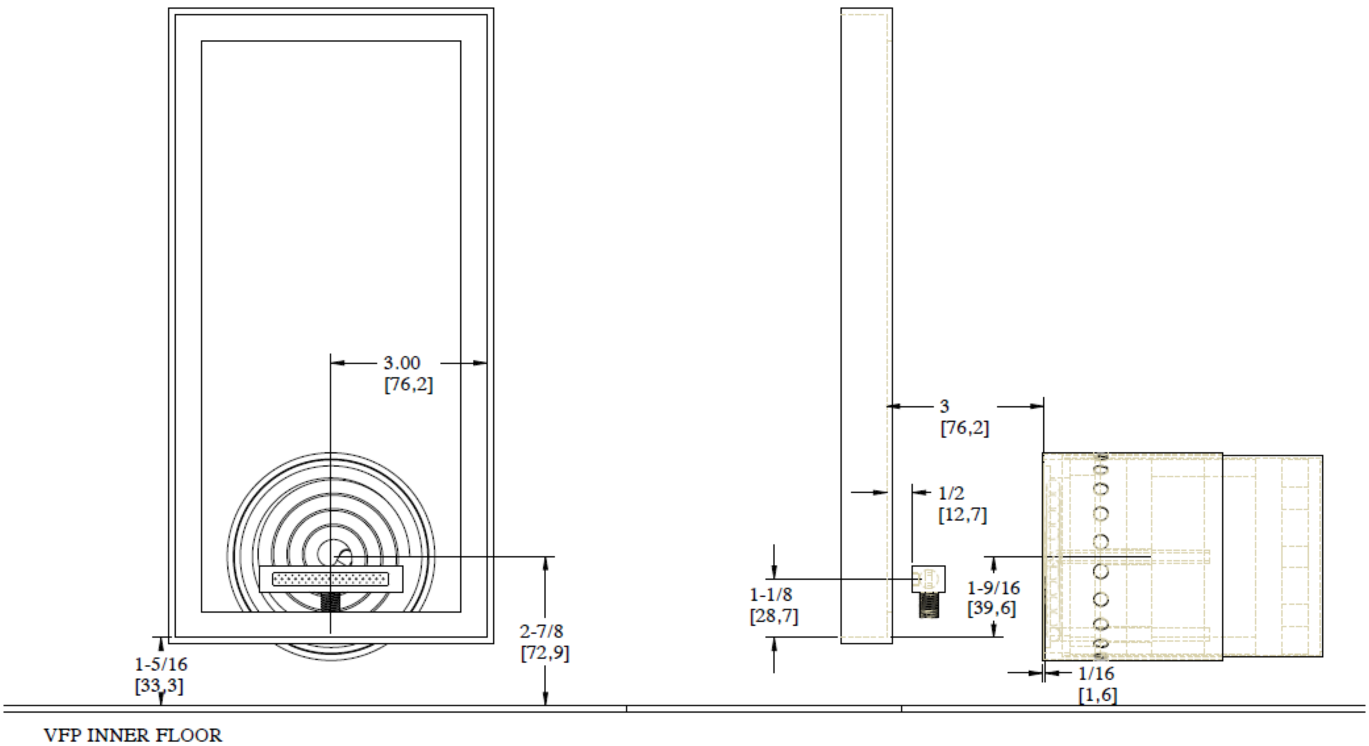


Figure N-9. Dimensioned drawing of the furnace mounting assembly

N.3.11 POWER CONTROLLER

Control and monitor the radiant furnace so that the power to the element maintains 706 watts ± 3 watts.

N.3.12 CURRENT MONITOR

The circuit providing power to the furnace should be monitored and recorded for current (amperes) and used to calculate resistance (ohms) to trace the health of the element.

An appropriate range should be used for electrical current measurement. This furnace, at approximately 110 volts, will require approximately 6.5 amps current. Therefore, the measurement range should place 6.5 amps between 10 percent and 100 percent of full scale. A 0–10 amp range will work for this application. The current must be monitored on one of the AC wires powering the furnace.

N.3.14 GAS AND AIR FLOWMETERS

The mass-flow controllers used should monitor values under 1 SLPM of fuel and 5 SLPM of air. The propane and air must be accurately measured to ensure proper operation of the ribbon burner. Propane is currently used at the FAA-TC to fuel the ribbon burner. The propane-to-air ratio is 0.26/3.8 SLPM. The methane to air ratio is 0.66/3.6 SLPM. The gas pressure is driven by the requirements of the mass-flow controller's manufacturer.

N.3.15 RIBBON BURNER

The ribbon burner is displayed in figure N-10. It is a uniform-flame uni-directional ribbon burner constructed of brass. The flame is directed horizontally.

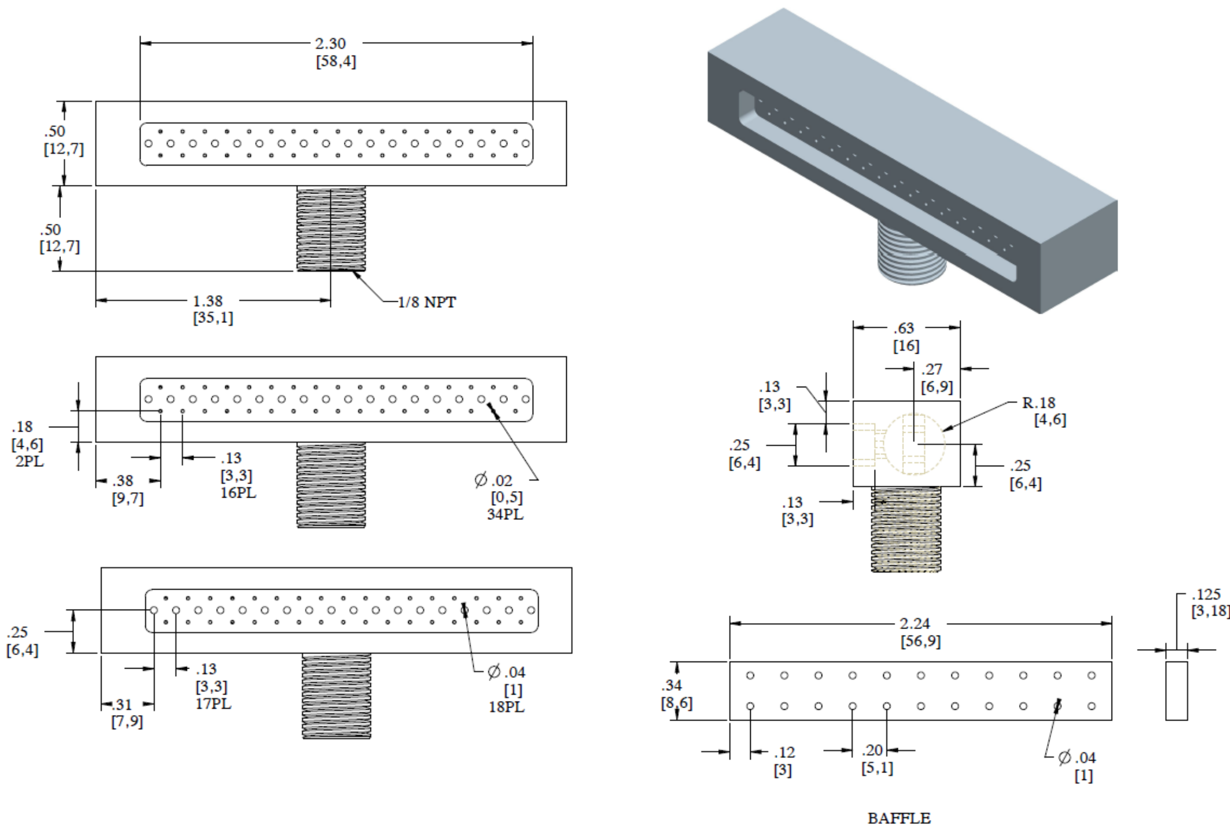


Figure N-10. Dimensioned drawing of the pilot burner

N.4.1 TEST APPARATUS CONFIGURATION

N.4.1.1 Furnace and Pilot Burner Alignment

The configuration of the furnace and pilot burner is displayed in figure N-11. The height of the furnace and the pilot flame are relative to the bottom inner surface of the sample frame, the point where the bottom edge of the test sample would be located. The centerline of the furnace coil is positioned 1.5625 inches above the bottom of the sample frame. The centerline of the ribbon burner face is positioned 1.125 inches above the bottom of the sample frame.

The furnace distance is measured relative to the inner vertical surface of the sample frame, where the plane of the test-sample surface would be located. The distance of the furnace coil from the inner vertical edge of the sample frame is 3 inches. The furnace coil is recessed from the outer edge of the furnace housing by 0.0625 inch. Figures N-12 through N-14 depict the assembled apparatus.

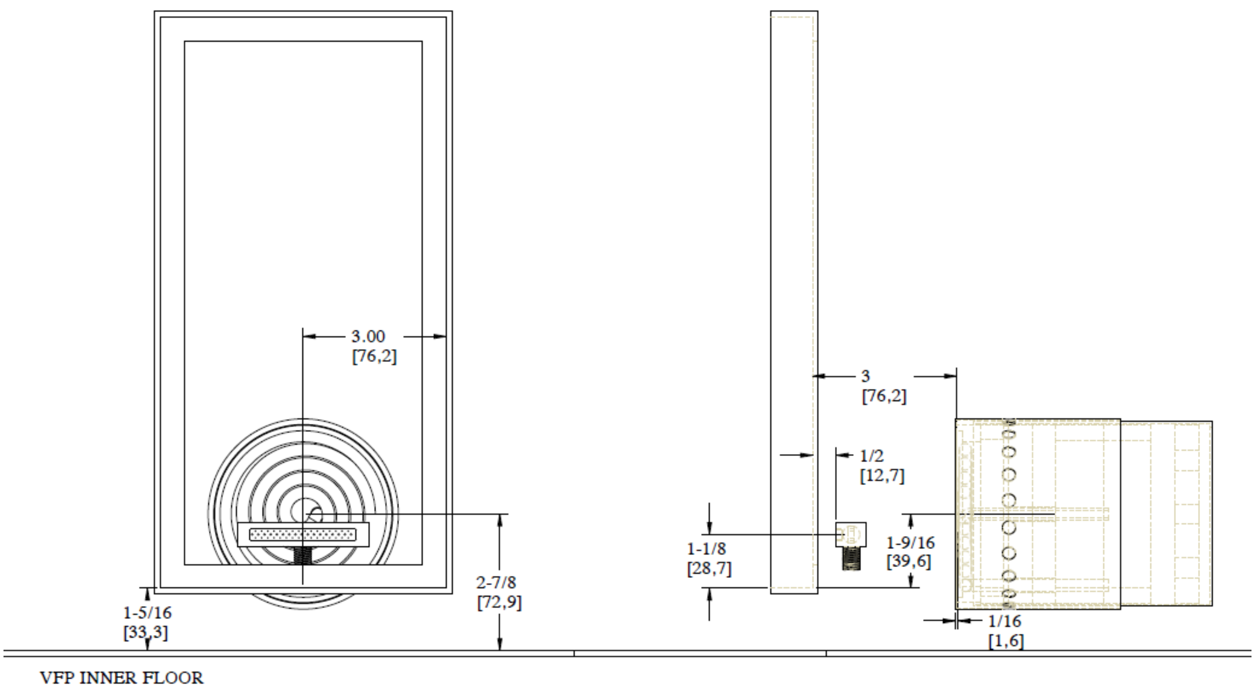


Figure N-11. Configuration of the sample frame, pilot burner, and radiant furnace

N.4.1.2 Completed and Assembled Images of VFP Test Apparatus

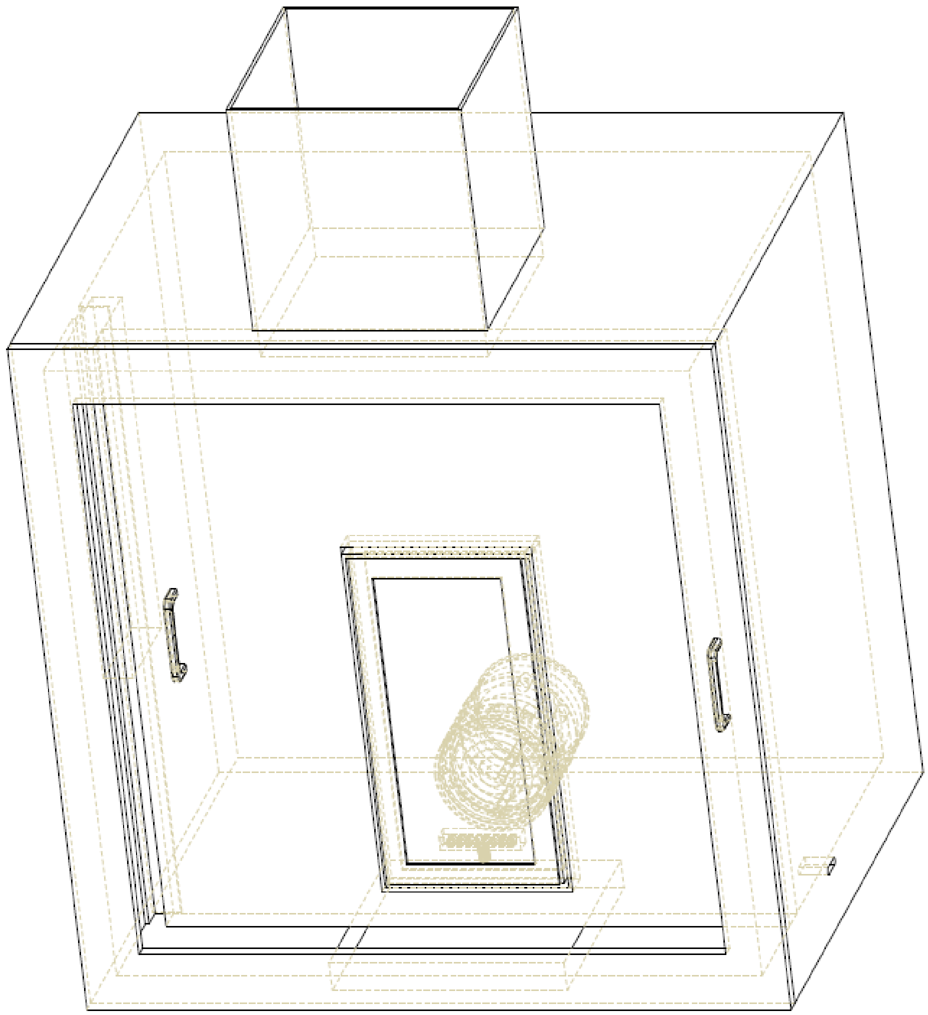


Figure N-12. VFP Test apparatus with both inner and outer doors closed

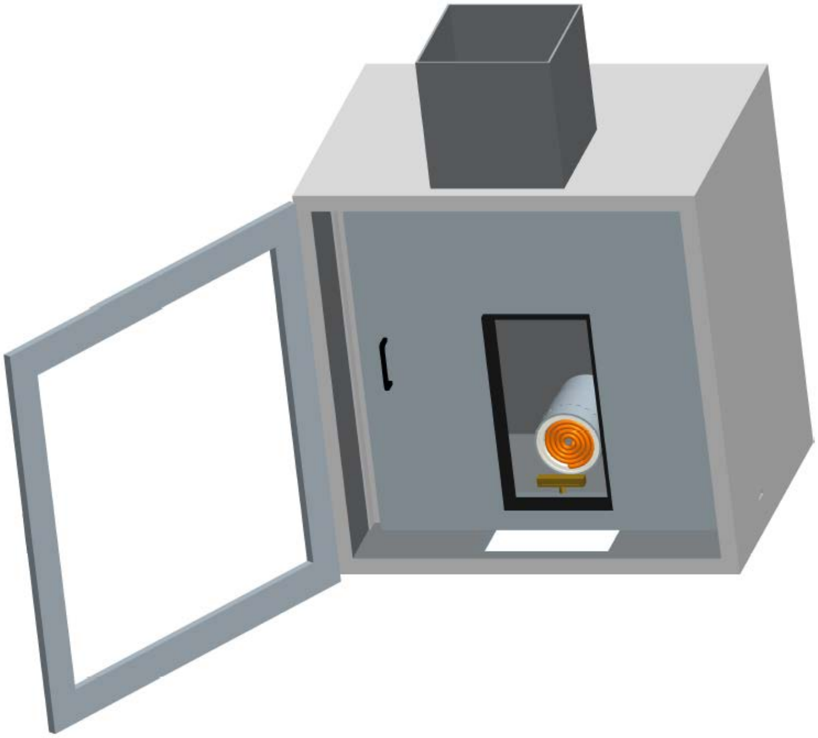


Figure N-13. VFP Test apparatus with sample door closed and no sample in place

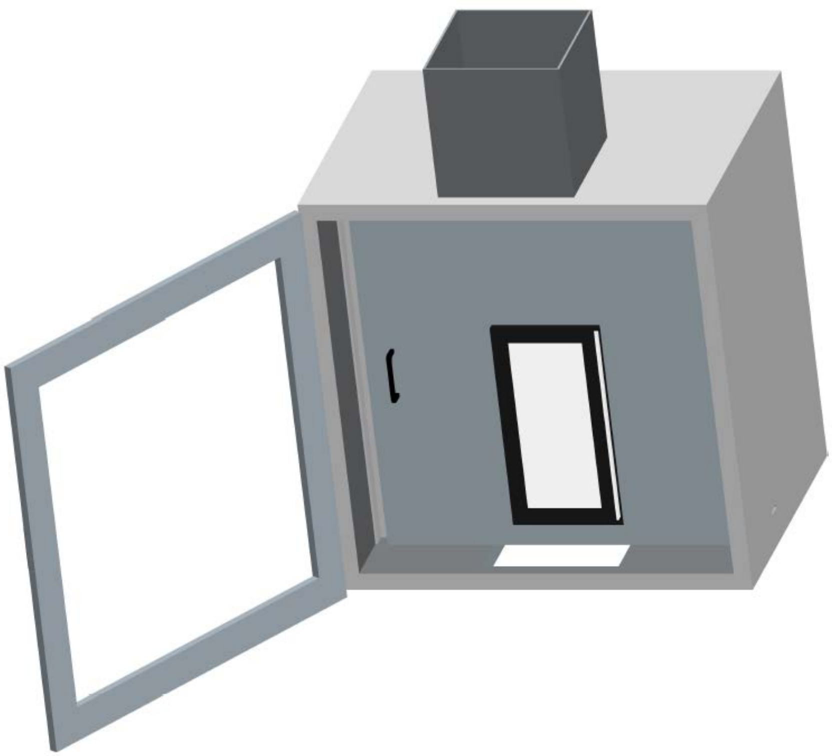


Figure N-14. VFP Test apparatus with sample door closed with sample in place