

Chapter 1

Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials

1.1 Scope

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

1.2 Definitions

1.2.1 Ignition Time

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

1.2.2 Flame Time

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

1.2.3 Drip Flame Time

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the specimen to the floor of the chamber. If no material falls from the specimen, the drip flame time is reported to be 0 seconds, and the notation “No Drip” is also reported. In the event that multiple drips fuel a flame, then the longest continuous flame shall be recorded.

1.2.4 Burn Length

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

1.3 Test Apparatus

1.3.1 Test Cabinet

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

1.3.2 Specimen Holder

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

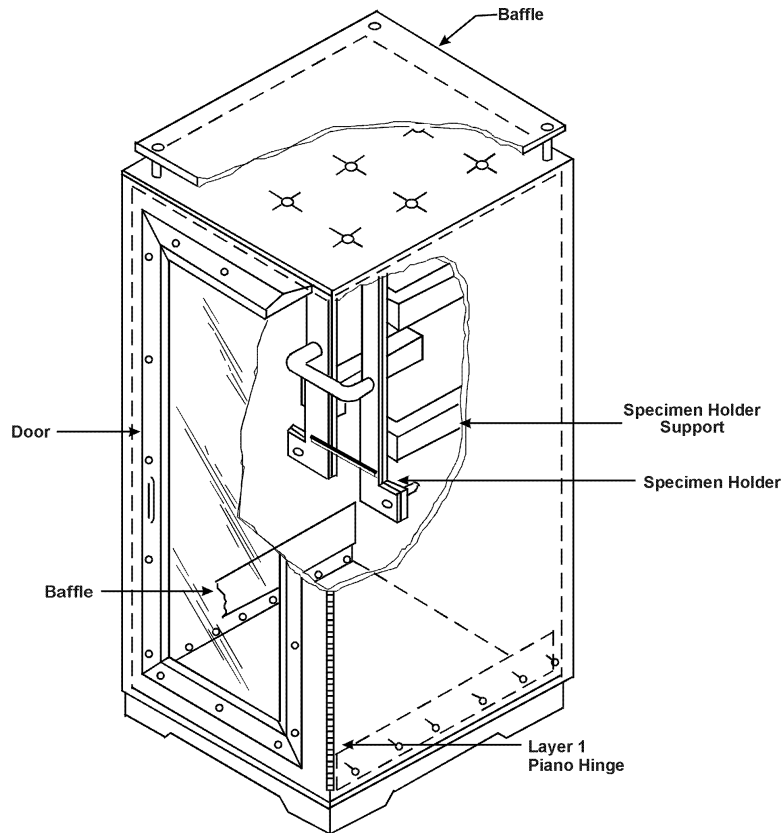


Figure 1-1. Sketch of Vertical Bunsen Burner Test Cabinet

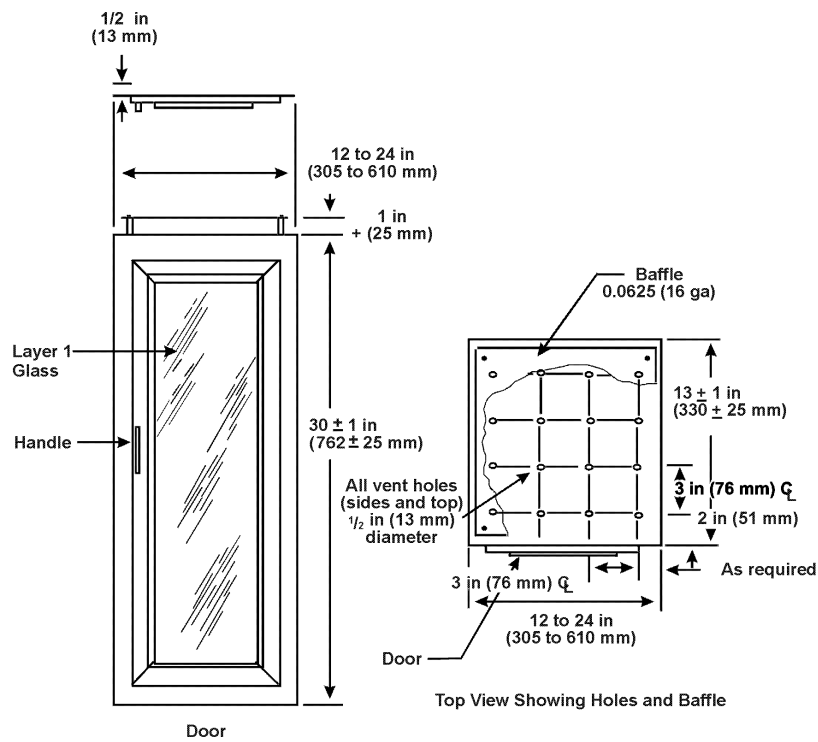


Figure 1-2. Front and Top View of Vertical Bunsen Burner Test Cabinet

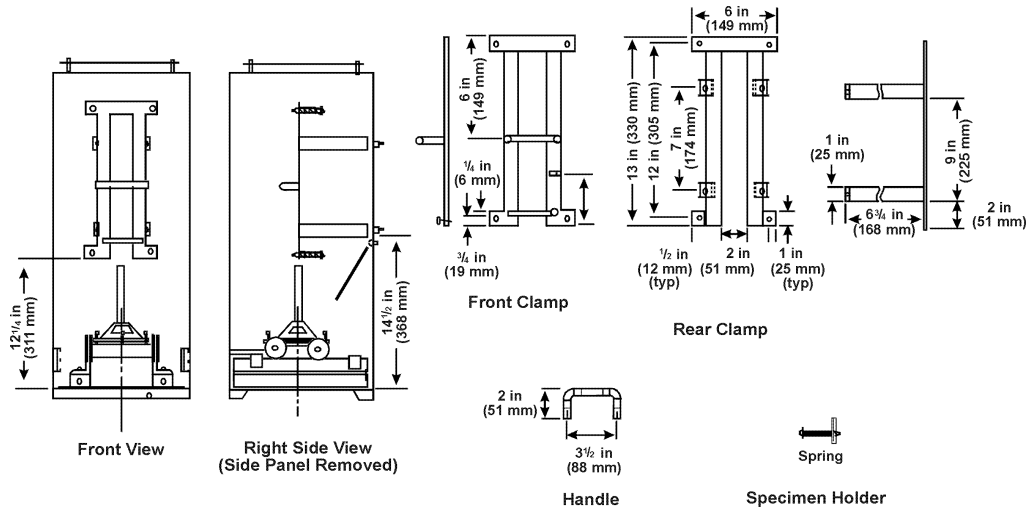


Figure 1-3. Vertical Bunsen Burner Test Specimen Holder

1.3.3 Burner

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

1.3.3.1 Burner Fuel

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

1.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure 1-4. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2.5 ± 0.25 psi (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

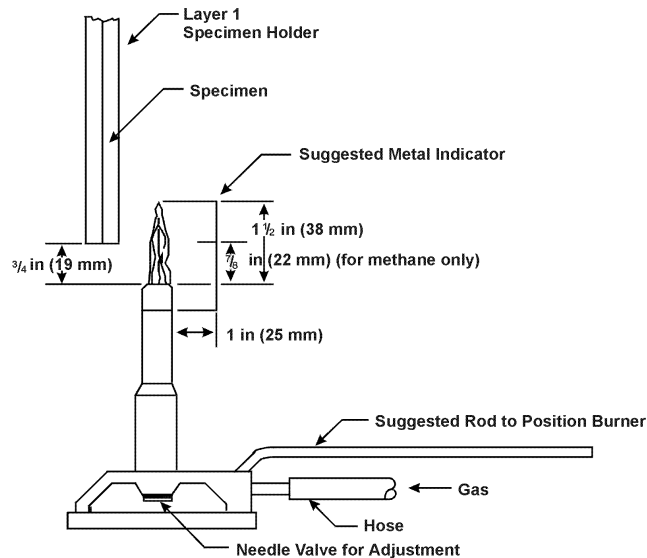


Figure 1-4. Burner Plumbing and Burner Flame Height Indicator

1.3.3.3 Flame Height Indicator

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

1.3.4 Timer

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

1.3.5 Ruler

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

1.4 Test Specimens

1.4.1 Specimen Selection

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

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

1.4.2 Specimen Number

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

1.4.3 Specimen Size

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

1.4.4 Specimen Thickness

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

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

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

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

1.5 Conditioning

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

1.6 Procedure

1.6.1 Burner Adjustment

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

1.6.2 Test Procedure

- 1.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.
- 1.6.2.2 Insert the specimen with its lower edge 3/4 inch (19 mm) above the level of the top of the burner.
- 1.6.2.3 Close the cabinet door, and keep it closed during the test.
- 1.6.2.4 Start the timer immediately upon positioning the burner. 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 1-5).

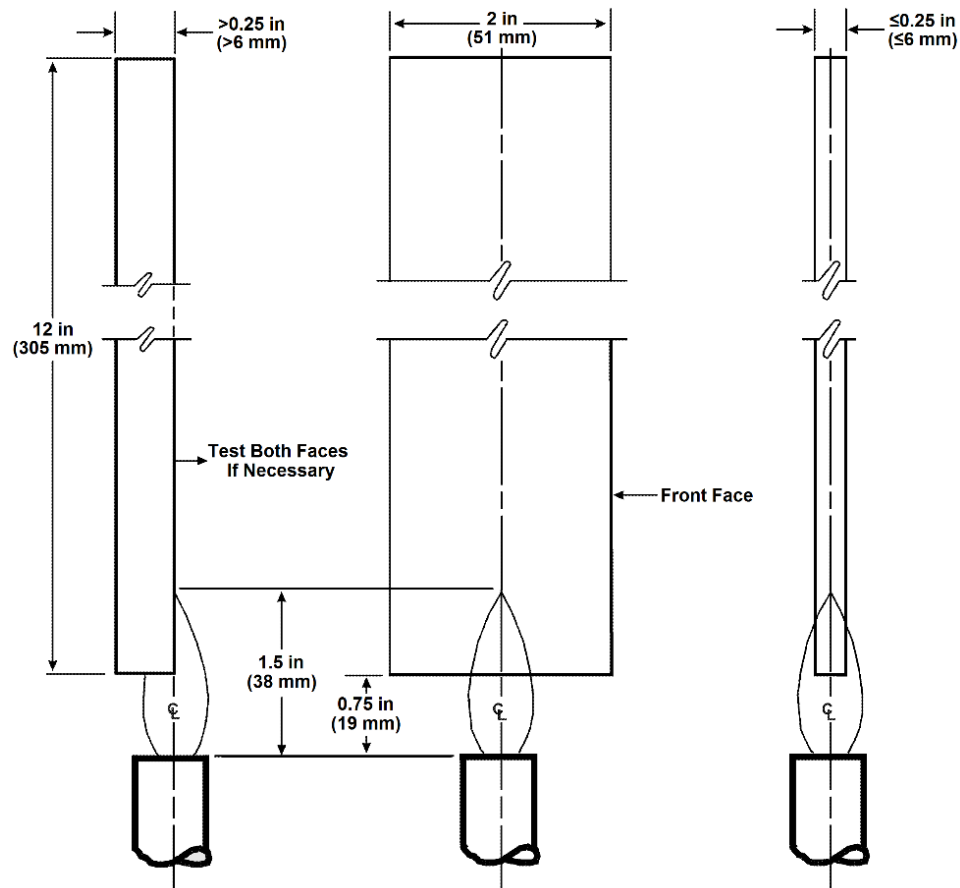


Figure 1-5. Flame Position on Vertical Specimens

- 1.6.2.5 Apply the flame for 12 seconds or 60 seconds, as appropriate, and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off.
- 1.6.2.6 If flaming material falls from the test specimen, determine the drip flame time for the specimen.
- 1.6.2.7 Determine the flame time for the specimen.
- 1.6.2.8 After all flaming ceases, open the cabinet door slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing smoke and fumes.
- 1.6.2.9 Remove the specimen and determine the burn length. The burn length shall be recorded from the sample face that had the longer burn length. If testing a sample that is greater than 0.25 inch thick, it is possible the longer burn length is from the non-tested face. It can be helpful to record the burn length from both faces, but it is not required. To aid in determining the burn length, a dry soft cloth or tissue, or a soft cloth or tissue dampened with a moderate solvent, such as methyl, ethyl, or isopropyl alcohol (which does not dissolve or attack the specimen material), may be used to remove soot and stain particles from tested specimens.
- 1.6.2.10 Remove any material from the bottom of the cabinet that fell from the specimen. If necessary, clean the test cabinet window and/or back face mirror prior to testing the next specimen.

1.7 Report

1.7.1 Material Identification

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

1.7.2 Test Results

1.7.2.1 Ignition Time

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

1.7.2.2 Flame Time

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

1.7.2.3 Drip Flame Time

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

1.7.2.4 Burn Length

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

1.8 Requirements

1.8.1 Flame Time

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

1.8.2 Drip Flame Time

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

1.8.3 Burn Length

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

Chapter 1 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

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

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

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

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

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

The following methods have been suggested for determining burn length:

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

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

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

- c. **Carpeting.** Tear the specimen with your hands. Use only enough force to tear the charred material. Stop when the fabric does not give way freely.
- d. **Polyurethane Foams.** Polyurethane foams are cellular in nature and, therefore, have low thermal conductivity. Since high surface temperatures are generated on exposure to the burner flame, an almost instantaneous conversion to flammable gases results. This, in turn, produces rapid surface flame spread

with complete consumption of the foam immediately above the ignition source. By definition, complete consumption of an area is part of the burn length and should be included.

Table 1-1. Loads for Determining Char Length

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

1.3.1 Suitable test cabinets of the type described are manufactured by Atlas Material Testing Technology, 1500 Bishop Ct., Mount Prospect, IL 60056; Custom Scientific Instruments, Inc., 1125 Conroy Place, Forks Industrial Park IV, Easton, PA 18040; Deatak, 4004 W. Dayton St., McHenry, IL 60050; Marlin Engineering, Inc., 2200 Division St., Suite A, Bellingham, WA 98226; SGS Govmark, 96-D Allen Blvd., Farmingdale, NY 11735-5626; and Thermtech Industries LLC, 8526 South Elwood, Tulsa, OK 74132.

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

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

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

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

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

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

1.3.3.3 The tip of the methane flame is blue, transparent, and difficult to see. It is more easily seen if there is no light on the flame, as in a darkened room. The inner cone of the flame is, however, more visible and easily seen and can be used to monitor flame height. When the flame height (blue transparent tip) is set to 1.5 inches, the height of

the inner cone has been found to vary slightly from burner to burner, but is generally about 7/8 inch. Therefore, if the inner cone height is used to monitor flame height, the inner cone height needs to be established for that burner.

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

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

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

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

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

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

1.6.2.4 More information is available in DOT/FAA/CT-86/22, "An Investigation of the FAA Vertical Bunsen Burner Flammability Test Method." Appendix F, FAR 25.853, Part I describes this test and specifies that the flame be placed "along the centerline of the lower edge." The "centerline of the lower edge" is the line from the front face to the back face of the specimen. For thicker specimens, this is ambiguous since exactly "where" along the "centerline of the lower edge" is not specified. For specimens that are 0.25-inch (6 mm) thick or less, place the burner barrel centerline under the center of the bottom surface of the specimen. For specimens thicker than 0.25 inch (6 mm), center the burner barrel under the midpoint of the lower edge of the front face of the test specimen (see figure 1-5).

For specimens thinner than the burner barrel thickness (3/8 inch; 10 mm), test results are relatively insensitive to exactly where "along the centerline of the lower edge" the burner flame is placed. For samples of greater thickness, however, burn lengths are typically an inch or so longer if the burner barrel centerline is placed under or near the specimen face, and flame times are sometimes a little longer than if the flame is placed per the original handbook, Report DOT/FAA/CT-89/15, September 1990.

Materials used in contemporary (especially post Amendment 25-61 which imposed heat release requirements) designs produce burn lengths and flame times that are considerably less than the acceptance criteria for certification (6 inches and 15 seconds), regardless of where the flame is placed. Although where the burner flame is applied is not of important pass/fail significance in this test, placing it directly under the specimen face generally represents a worst-case situation, and should be used.

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

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

1.6.2.9 It is acceptable to use the opposite end of a previously tested sample to test the opposite face in a subsequent test if the burn damage of the non-tested face is less than 3 inches (76.2 mm) for the 12-second vertical test or 5 inches (127 mm) for the 60-second vertical test. Burn damage is not the same as burn length, as this would include any damage from warping, melting, or shrinking away.