

Chapter 19 (D9) Smoke Test for Insulated Aircraft Wire

19.1 Scope

19.1.1 Applicability

This test method is used to determine the smoke generating characteristics of insulated aircraft wire using a smoke density chamber.

19.2 Definitions

19.2.1 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, due to coagulation of smoke particles or to adsorption of smoke particles to the walls of the chamber, it is possible for the maximum to occur earlier in the test.

19.3 Test Apparatus

19.3.1 Required Equipment

The test chamber and related equipment (e.g., radiant heat furnace, heat flux density gauge, sample holder, photometric system, straight pilot burner, etc.) will be as defined below:

19.3.1.1 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 19-1. The location or size of items such as the chamber door, chamber controls, flowmeters, etc., 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.

19.3.1.1.1 The interior surfaces (except for the chamber door, vents, etc.) will be porcelain-enameled metal or equivalent coated metal that is resistant to chemical attack and corrosion and suitable for periodic cleaning.

19.3.1.1.2 The chamber will be equipped with a door such as that indicated in figure 19-1 to provide convenient access for changing test samples 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.

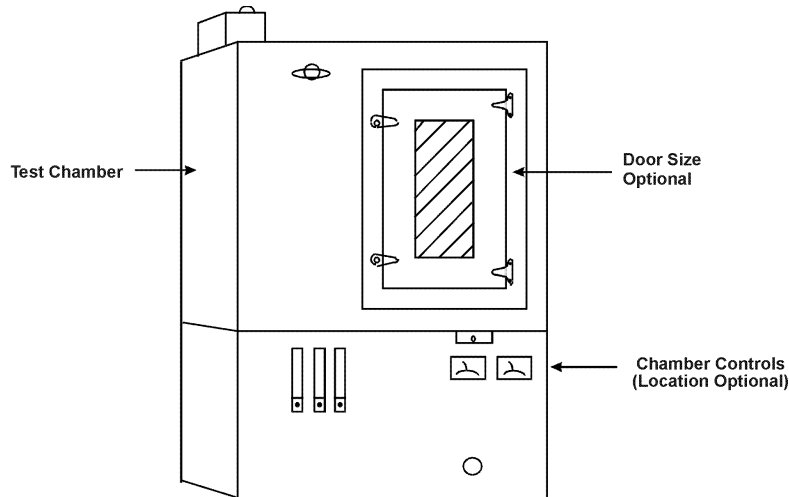


Figure 19-1. Typical Smoke Density Chamber

19.3.1.1.3 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.

19.3.1.2 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.

19.3.1.3 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.

19.3.1.4 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.

19.3.1.5 Electric Power

Six hundred fifty watts of 115V, 60 Hz, single phase electric power will be provided for the radiant heat furnace and accessories. Where 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.

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.

19.3.1.6 Radiant Heat Furnace

An electric furnace and associated controlling devices, such as shown in figures 19-2 and 19-3, will be provided that are capable of providing a constant thermal flux density of $2.5 \pm 0.05 \text{ W/cm}^2$ ($2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$) on the sample surface.

NOTE: Furnace model P/N 6806025700 from Newport Scientific has been found acceptable.

19.3.1.6.1 Furnace Construction

The dimensions shown in figure 19-2 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.

19.3.1.6.2 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 19-3.

19.3.1.6.3 Furnace Control System

The furnace control system will be capable of controlling the radiant heat output at the required level of $2.5 \pm 0.05 \text{ W/cm}^2$ ($2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$), 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 General Electric Company, 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.

It is recommended to use a digital voltmeter to monitor the furnace voltage output and a digital amperemeter to monitor the furnace current.

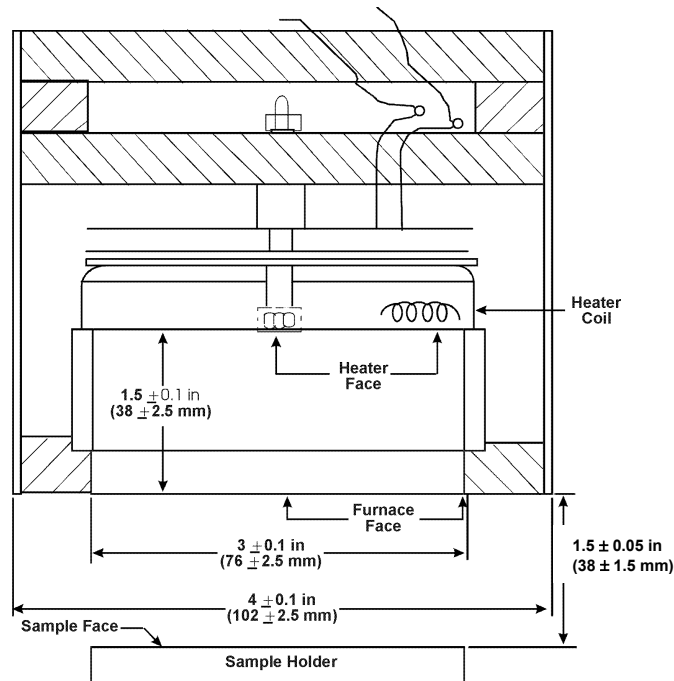


Figure 19-2. Furnace Section

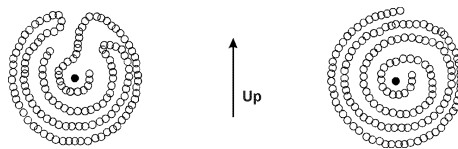


Figure 19-3. Heater Orientation

19.3.1.6.4 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 $200 \pm 2^\circ\text{F}$ 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.

19.3.1.6.4.1 Compressed air at a pressure of 15 to 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 (13- by 13- by 38-mm) - long 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.

19.3.1.7 Pilot Burner

The straight burner must be used for flaming tests on insulated wire samples, as shown in figure 19-4. 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 19-10. Care should be taken to ensure accurate positioning of the pilot tips to the sample holder.

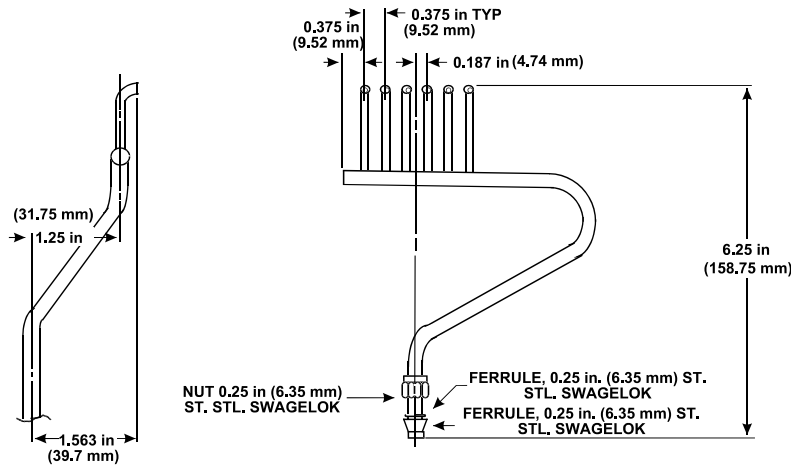


Figure 19-4. Straight Tip Burner

19.3.1.7.1 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 19-5, 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.

19.3.1.7.2 The pilot burner will be centered in front of and parallel to the sample 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 sample holder and 0.25 ± 0.03 inch (6.4 ± 0.8 mm) from the face of the sample surface.

19.3.1.8 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 air flow rate equivalent to 0.018 ± 0.001 ft³/min (500 ± 20 cm³/min) at STP and a propane flow rate equivalent to 0.0018 ± 0.0001 ft³/min (50 ± 3 cm³/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.

19.3.1.8.1 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 19-6. If the flamelets are not that approximate size, there is probably a difficulty with the air/propane fuel mixture and/or flow rate(s), in which case, the accuracy of the flowmeters should be checked.

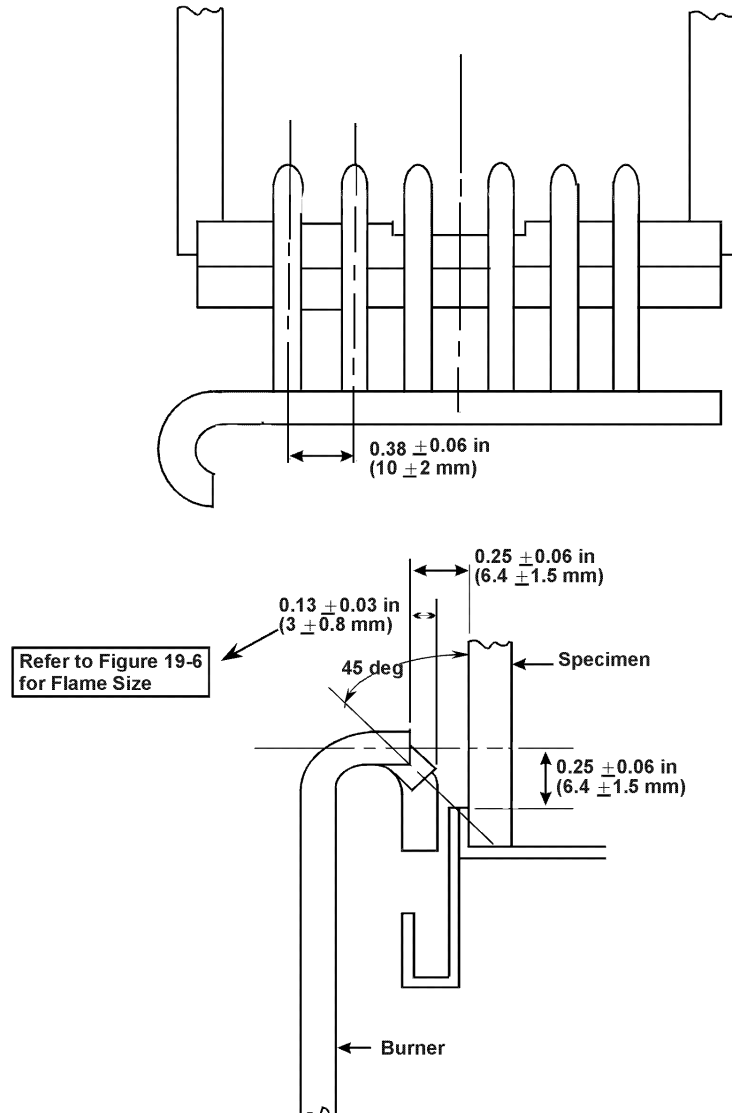


Figure 19-5. Alignment of Holder and Burner

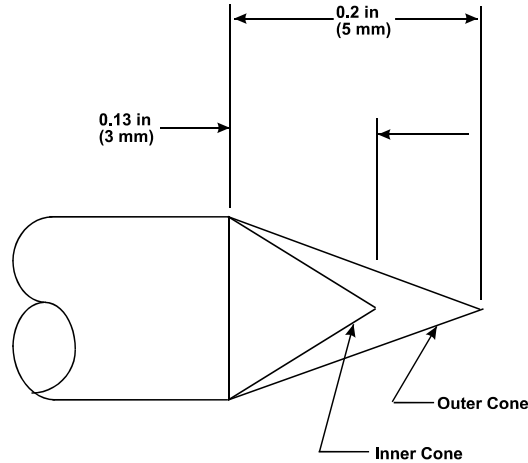


Figure 19-6. Flame Size

19.3.1.9 Sample Holder

The sample holder will consist of a stainless steel frame, a backing made of insulation millboard, a spring and retaining rod to secure the sample in place, and aluminum foil for wrapping the sample.

19.3.1.9.1 Sample Holder Frame

The sample holder frame will be fabricated of stainless steel sheet by bending and brazing (or spot welding) stainless steel sheet of 0.025 ± 0.002 -inch (0.64 ± 0.05 -mm) nominal thickness to conform in shape and dimension to figure 19-7. The frame will be at least 1.5 inches (38 mm) deep and will provide an exposed sample surface that is nominally 2.56 by 2.56 inches (65 by 65 mm) and that is at least 6.5 inches² (4,194 mm²) in area.

NOTE: Sample holders must be checked for accuracy with each other; for example, top and bottom mounting devices consistent with each other. It has been noted that misalignment between holders does result in pilot position errors.

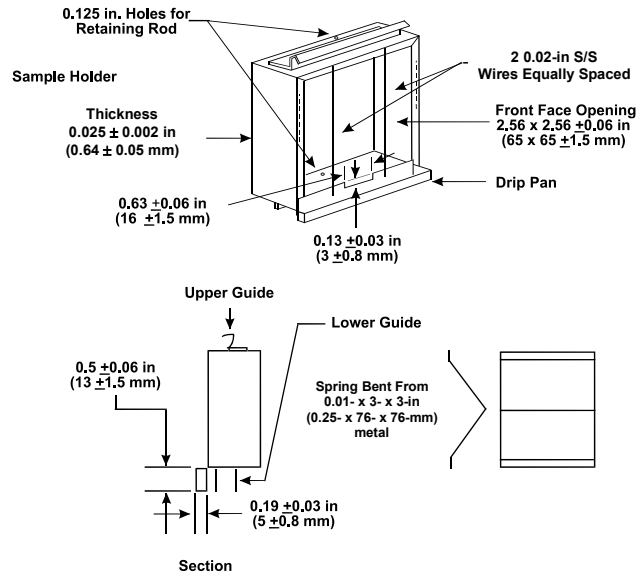


Figure 19-7. Details of Sample Holder

19.3.1.9.1.1 A drip pan to catch and retain dripping material will be attached to the bottom front of the holder.

19.3.1.9.1.2 Guides to permit accurate alignment of the exposed sample area in front of the furnace opening will be attached to the top and bottom of the holder frame.

19.3.1.9.2 Sample Backing

A piece of insulation millboard will be used as a backing for the sample and as a simulated blank sample. The millboard will be nominally 0.5 inch (13 mm) thick with a density of $50 \pm 10 \text{ lb/ft}^3$ ($0.8 \pm 0.16 \text{ g/cm}^3$) or equivalent. Pieces will be cut 2.91 ± 0.03 by 2.91 ± 0.03 inch (74 ± 1 by 74 ± 1 mm) to fit inside the sample holder.

NOTE: A recommended material is Marinite I.

19.3.1.9.3 Retaining Spring

A spring bent from 3- by 2.94- by 0.01-inch (76- by 75- by 0.25-mm) -thick stainless steel sheet will be used with a stainless steel retaining rod to securely hold the sample and millboard backing in position during testing.

19.3.1.9.4 Aluminum Foil

Smooth aluminum foil that is 0.0012 ± 0.0005 inch (0.03 ± 0.01 mm) thick will be used to wrap test samples prior to their insertion in the holder.

NOTE: Aluminum foil used for household food wrapping is acceptable.

19.3.1.10 Support for Radiant Heat Furnace and Sample Holder

A typical support frame to support the radiant heat furnace and sample holder is shown in figure 19-8. 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 sample surface. Adjustment screws will be provided to

align the furnace with reference to the sample. The framework will have two 0.38-inch (10-mm) -diameter transverse rods of stainless steel to accept the guides of the sample holder. The rods will support the holder so that the exposed sample 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 sample holder. An externally operated control rod will be provided to replace the test sample with the blank sample holder in front of the furnace.

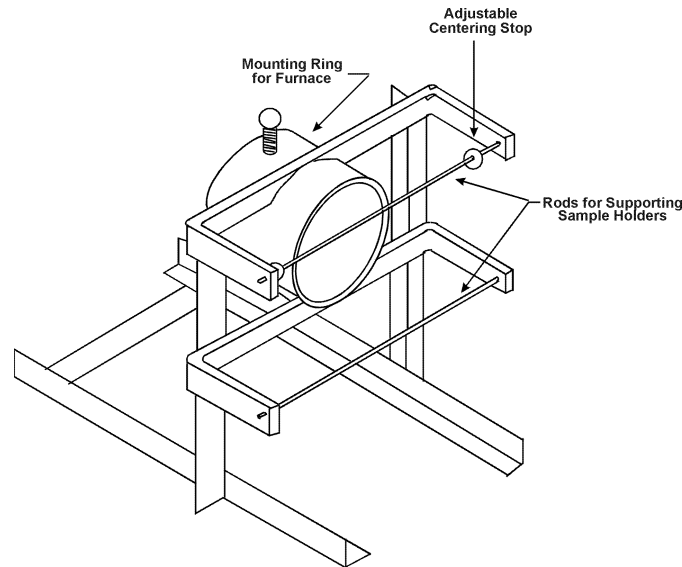


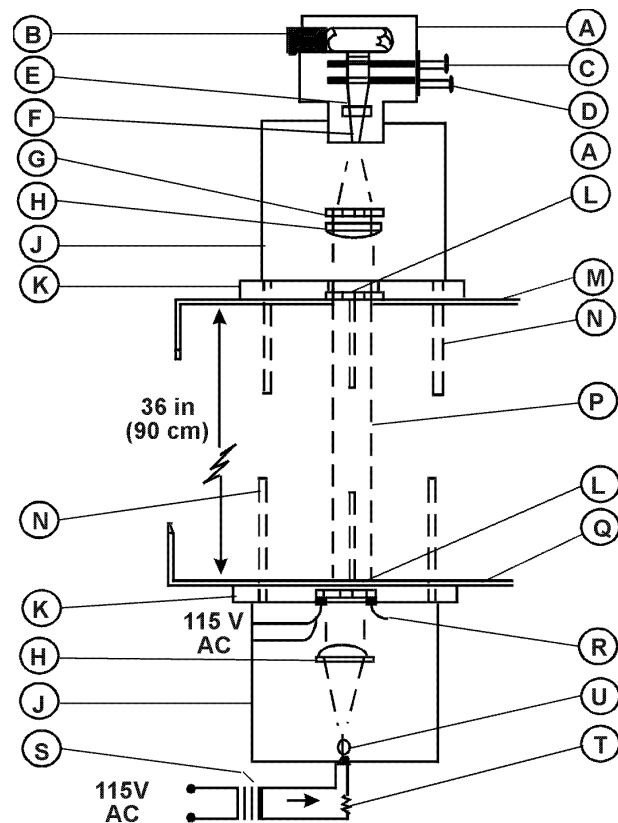
Figure 19-8. Typical Furnace Support

19.3.1.11 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 optical density, to stratification of the smoke in the chamber during the test, a photomultiplier microphotometer that converts the photomultiplier tube output to relative intensity and/or to and a strip chart recorder or other suitable means to record light transmission versus time. A typical system is shown in figures 19-9 and 19-10.

19.3.1.11.1 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 $2200 \pm 100\text{K}$ 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 19-9. Photometer Detail

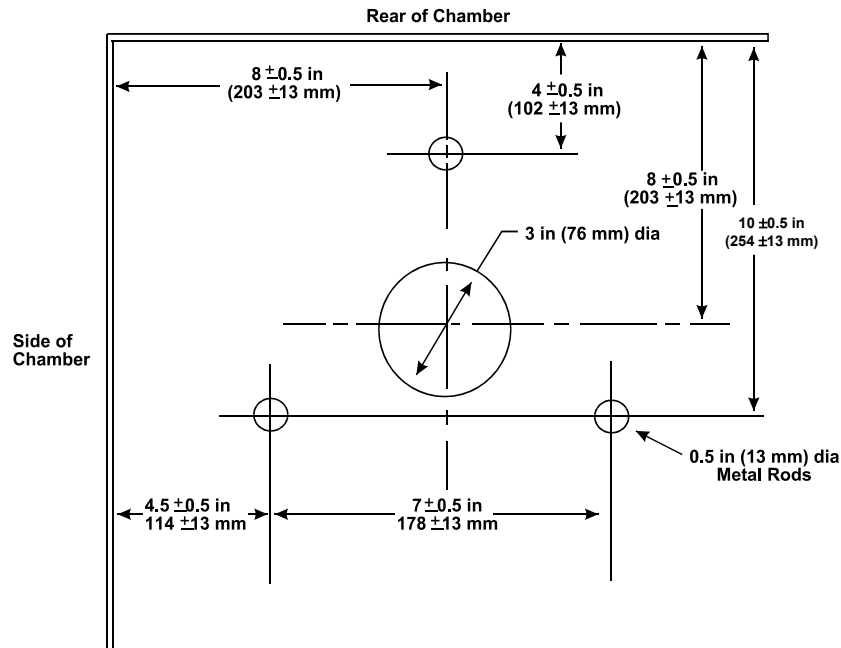


Figure 19-10. Optical System Location Plan View

19.3.1.11.2 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.

19.3.1.11.2.1 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 and permits 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.

19.3.1.11.3 Microphotometer

The microphotometer will be capable of converting the signal from the photomultiplier tube to relative intensity and/or 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.

19.3.1.11.4 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 (8-mm) - thick externally mounted top and bottom plates and symmetrically arranged about the collimated light beam.

19.3.1.11.5 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 and/or photomultiplier tube changes sensitivity through aging and/or as discoloration or deterioration of the optical windows occurs.

19.3.1.11.6 Recorder

A recording device will be furnished that provides a record of the percent of light transmission and/or optical density versus time during the test. The record will consist either of a continuous curve on a chart recorder or discrete values taken at least every 5 seconds with a computerized data acquisition system.

19.3.1.12 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.

19.3.1.13 Conditioning Chamber

A conditioning chamber capable of maintaining test samples at a temperature of $70 \pm 5^\circ\text{F}$ ($21 \pm 3^\circ\text{C}$) and $50\% \pm 5\%$ relative humidity will be provided.

19.3.2 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 Auto-ranging Multi-meter or equivalent has been found acceptable.

Constant Voltage Transformer—A constant voltage transformer is recommended for all installations (see section 19.3.1.5).

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 pilot burner after removal and replacement (see figure 19-10).

Automated Igniter System—An automated igniter system is recommended to relight the pilot burner flamelets to ensure that none of them extinguishes 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.

19.4 Test Sample Selection and Preparation

19.4.1 Sample Number

A minimum of three samples will be prepared and tested.

NOTE: Conditions may require as many as six samples. Samples should be marked with an arrow by manufacturers or operator for a consistent direction for test purposes.

19.4.2 Sample Size

Insulated wire samples, 16 AWG and smaller, will be wrapped on the frame, as shown in figure 19-11. 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. Samples 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 sample 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 sample holder. The pieces of wire are then inserted through the front of the holder and held vertically. This is shown in figure 19-12.

19.4.3 Sample Orientation

Insulated wire samples will only be tested in a vertical orientation.

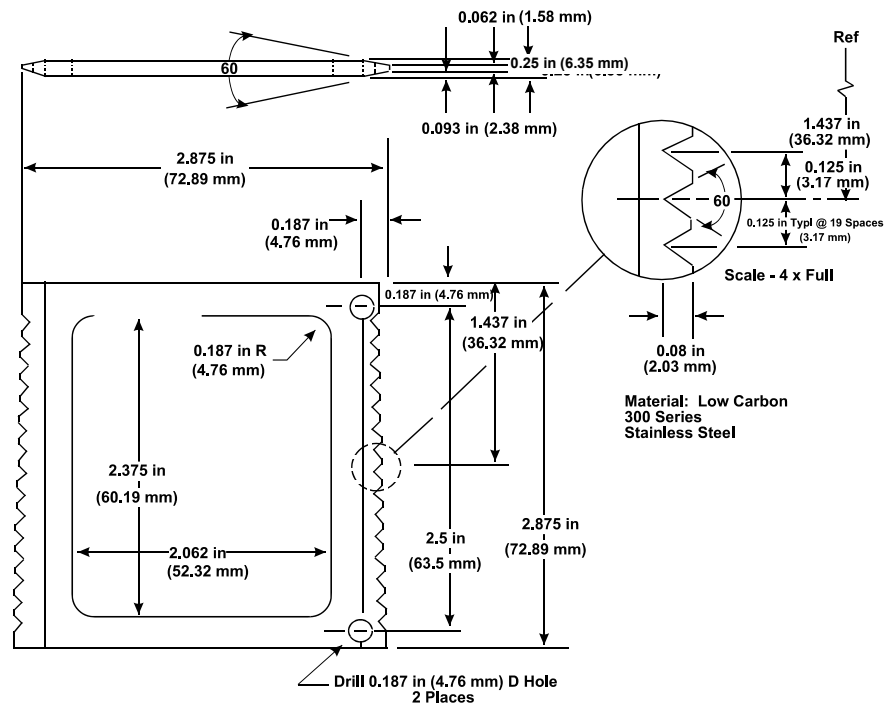
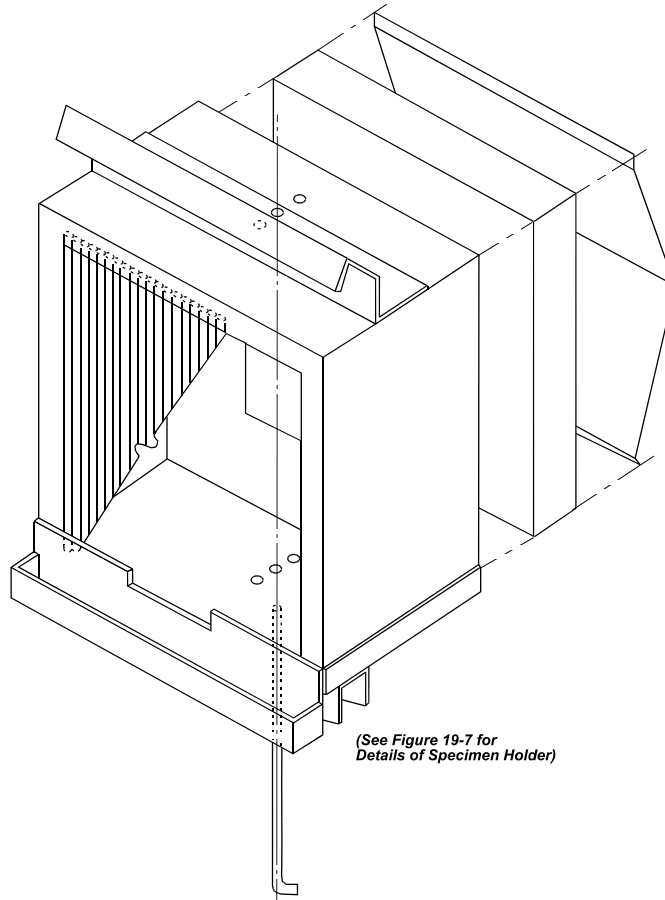


Figure 19-11. Wire Holding Frame



(See Figure 19-7 for
Details of Specimen Holder)

Figure 19-12. Larger Gauge Wire Mounted in Sample Holder

19.5 Test Chamber Calibration

19.5.1 Furnace Protection

Prepare a blank sample consisting of 0.5-inch-thick alumina-silica millboard mounted in a sample 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 sample in front of the furnace when no testing or calibration is being conducted.

19.5.2 Periodic Calibration Procedure

Conduct a periodic calibration of the system as follows.

19.5.2.1 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. If erratic behavior is observed or suspected, check the system more frequently.

19.5.2.2 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 sample 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 $200 \pm 50^{\circ}\text{F}$ ($93 \pm 3^{\circ}\text{C}$). 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 $2.5 \pm 0.05 \text{ W/cm}^2$ ($2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$). 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 sample holder.

19.5.2.2.1 Record the setting of the furnace control voltage or power controller and use this setting until a future calibration indicates it should be changed.

19.5.2.3 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.

19.5.2.3.1 Place the heater switch in the OFF position. Close the inlet vent and the chamber door.

19.5.2.3.2 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.

19.5.2.3.3 Note the chamber pressure. Verify that the chamber pressure leakage rate is less than 2 inches of water in 2 minutes.

19.5.2.4 Total System

Check the total system at least once a month by testing a material that has shown a consistent sample-to-sample 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.

19.5.3 Chamber Cleaning

Clean the optical system windows, viewing window, chamber walls, and sample holders as follows.

19.5.3.1 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 because wax will cause the smoke to adhere to the glass more quickly.

19.5.3.2 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.

19.5.3.3 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.

19.5.3.4 Sample Holders

Remove any charred residues on the sample holders and horizontal rods securing the holder position to prevent contamination of subsequent samples.

19.6 Procedure

19.6.1 Each day, prior to testing, adjust the chamber as follows:

19.6.1.1 Calibrate the furnace output according to section D4.6.2.3 to determine the correct furnace voltage.

19.6.1.2 Balance the photomultiplier dark current and set the clear beam reading to 100 percent relative transmission or to optical density 0.00.

19.6.1.3 Set the photomultiplier scale at 100. Shut lower shutter blade (D) directly below photomultiplier tube (B) (see figure 19-9). Set your data recording device to zero.

NOTE: During testing at the FAA William J. Hughes Technical Center, a software-related problem was discovered with the calculation of Ds 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 can be detected by the computer. The problem is that the current software assumes the initial value is zero 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 Ds around the pass/fail point of 200 critical. A ± 1 millivolt initial reading can change an actual Ds 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:

$$\text{Slope} = \frac{100}{(\text{mV}_H - \text{mV}_b)}$$

$$\% \text{ L.T.} = (\text{mV} - \text{mV}_b) * \text{Slope}$$

19.6.2 Conduct the test procedure as follows:

19.6.2.1 Ensure that the sample(s) have been properly prepared per sections D4.4.1 through D4.4.5.

19.6.2.2 Ensure that the chamber wall temperature is $95 \pm 4^\circ\text{F}$ ($35 \pm 2^\circ\text{C}$).

19.6.2.3 Ensure that the furnace voltage has been set correctly.

19.6.2.4 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.

19.6.2.5 Position the pilot burner in front of and parallel to the sample 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.

19.6.2.6 Open the test chamber door and place the sample holder on the support. Immediately push the sample holder into position in front of the furnace, displacing the blank sample holder to the prepositioned stop, and close the chamber door and inlet vent. For chambers with an external device to move the sample 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.

19.6.2.7 Continue the test for a minimum of 20 minutes (1200 seconds).

19.6.2.8 Record the percent of light transmission and/or optical density versus time (minutes) during the test.

19.6.2.9 Monitor the chamber pressure during the test. If negative pressure (below ambient atmospheric) develops, open the inlet valve slightly to relieve pressure.

19.6.2.10 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.

19.6.2.11 At the termination of the test, remove the test sample holder from its position in front of the furnace and replace it with the blank sample 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.

19.6.2.12 Continue to exhaust the chamber until all smoke has been removed.

19.6.2.13 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.

19.6.2.14 Record the D_s for each sample at the 20-minute point. Calculate and record the maximum specific optical density, D_m , during the 20-minute (1200-second) test for each sample 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 ft³ (0.510 m³)

L = light path length = 3.00 ft (0.914 m)

A = exposed sample area = 6.57 in² (0.00424 m²)

T_m = minimum percent light transmission during 20 minutes

$\log_{10}(100/T_m)$ = maximum optical density during 20 minutes

19.6.2.15 Calculate and record the average D_m value and its standard deviation for all the samples 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.

19.7 Report

19.7.1 Report a complete identification of the part/construction tested such as insulation type, gauge, etc.

19.7.2 Report the number of samples tested (the average D_m).

19.7.3 Report any additional data or observations, as applicable and/or required by the test plan.