

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.2.3 REFRACTORY BOARD

A high-temperature, non-combustible, rigid insulation board with a maximum thermal conductivity of $0.694 \text{ Btu}\cdot\text{in}/\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}$ ($0.10 \text{ W}/\text{m}\cdot\text{K}$) at 500°F (260°C).

M.2.4 HEAT FLUX

The intensity of the thermal environment to which the sample is exposed when burned, measured in $\text{BTU}/\text{ft}^2\text{sec}$ or W/cm^2 .

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 $0.694 \text{ Btu}\cdot\text{in}/\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}$ ($0.10 \text{ W}/\text{m}\cdot\text{K}$) at 500°F (260°C). 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.

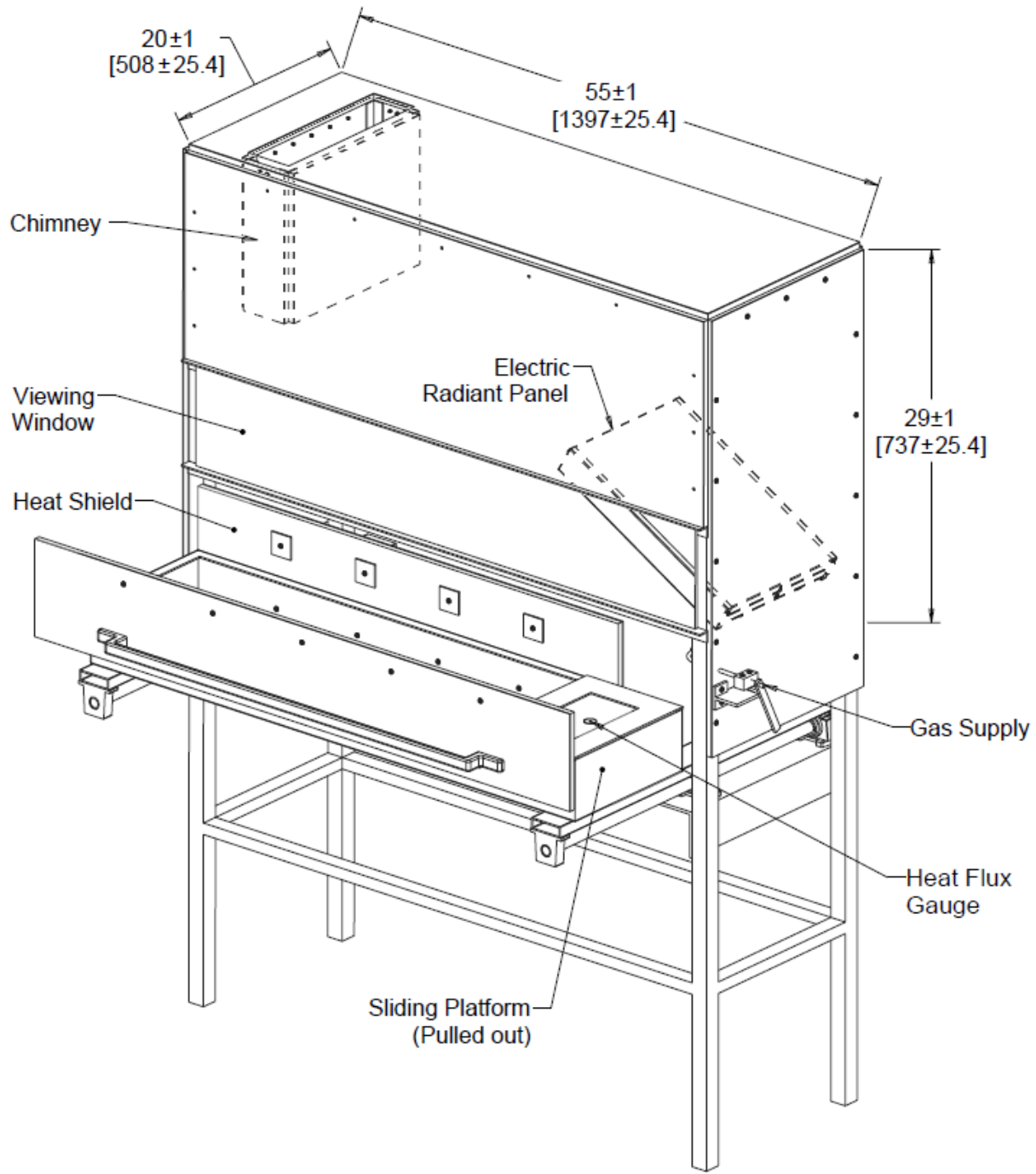
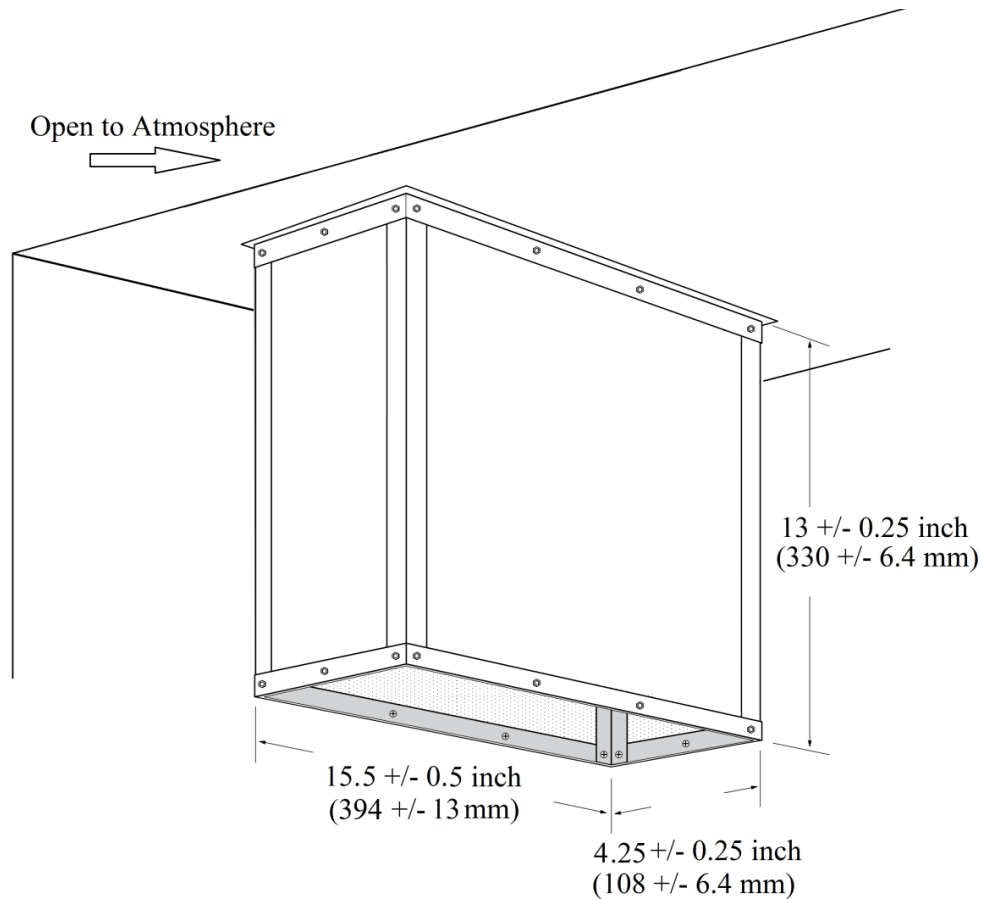


Figure M-1. Test chamber

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 refractory board. The interior dimensions of the chimney are 4.25 ± 0.25 inches wide (108 ± 6 mm), 15.5 ± 0.5 inches (394 ± 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.

NOTE: The high-temperature refractory 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, ½ inch and ¼ inch thicknesses.



0.125 inch (3.2 mm) Angle Iron (8 places)
 0.125 inch (3.2 mm) Flat Stock (4 places)
 0.5 inch (13 mm) Insulation Board (4 places)
 0.0625 inch (1.6 mm) Sheet Metal (4 places)

Figure M-2. Interior view of internal chimney

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 $1100^{\circ} \pm 50^{\circ}\text{F}$ ($593^{\circ} \pm 27^{\circ}\text{C}$). 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 is 10799-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.

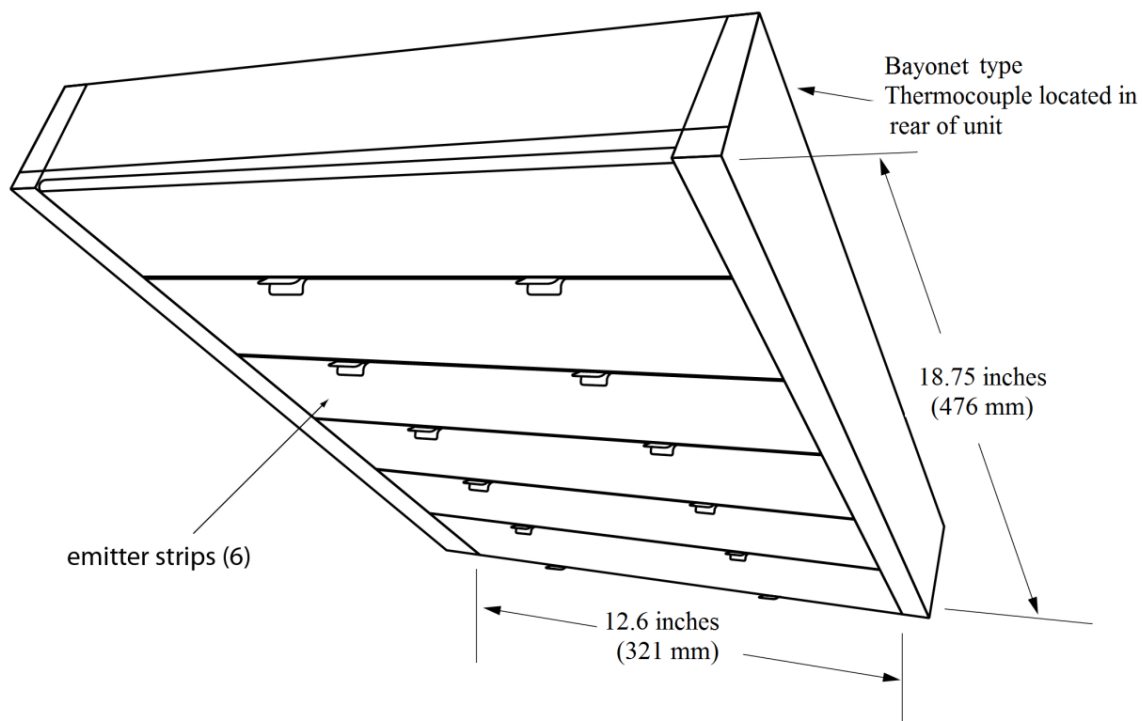


Figure M-3. Electric radiant panel

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 inches (± 6 mm) See figure M-4.

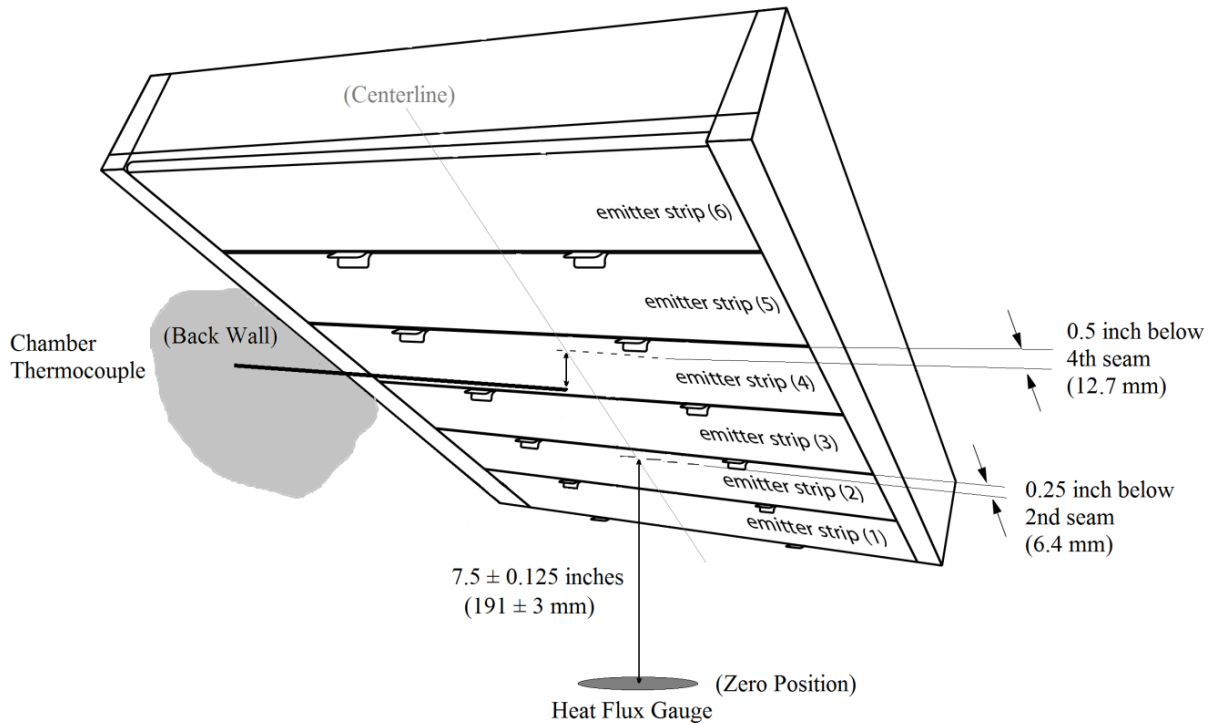


Figure M-4. Electric radiant panel placement

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 a minimum 2 inches (51 mm) deep and may be up to 6 inches (152 mm) deep. It may be necessary to use shims and/or multiple sheets of refractory 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 not allow any convective airflow through.

The test sample must be placed on a sheet of refractory 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 stabilize. Heat soak the new boards for approximately one 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 refractory 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.

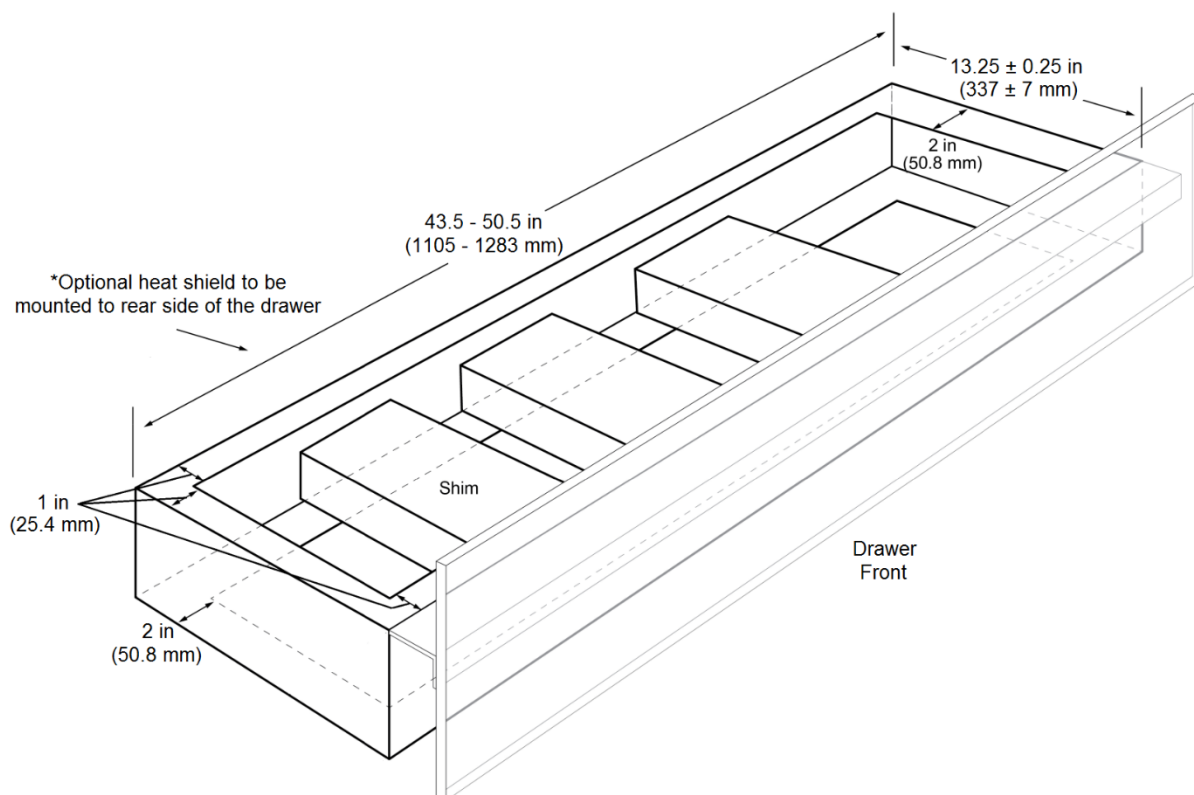


Figure M-5. Sliding platform

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 each of 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.

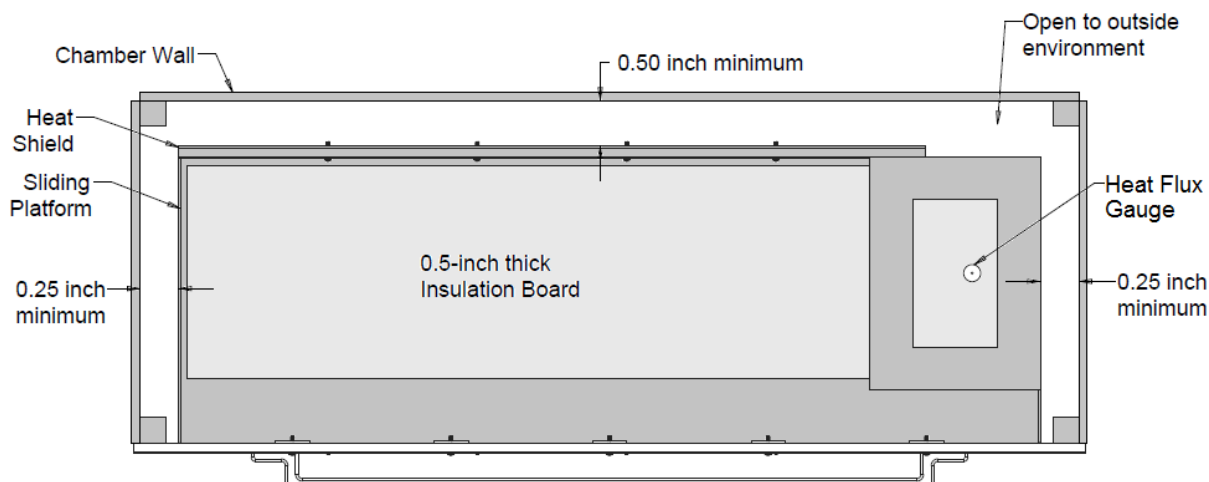


Figure M-6. Open area around the sliding platform

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 inches (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 provided it is 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.

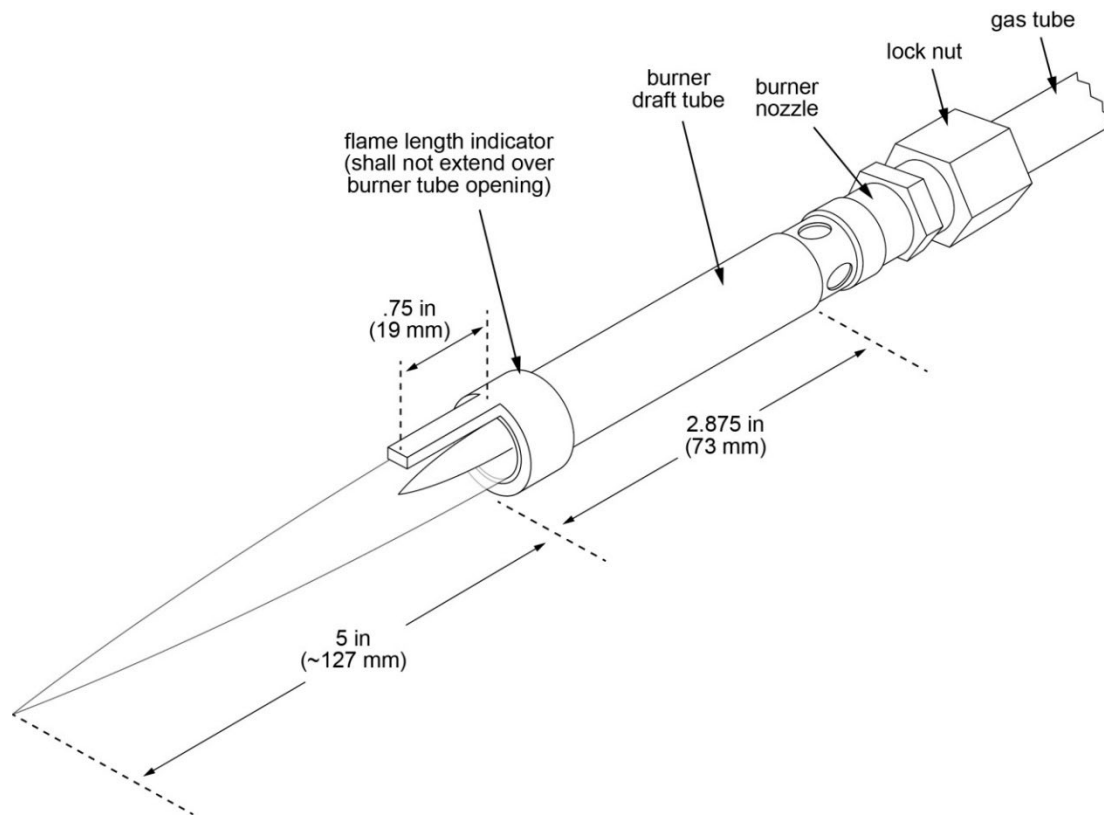


Figure M-7. Propane venturi torch (pilot burner)

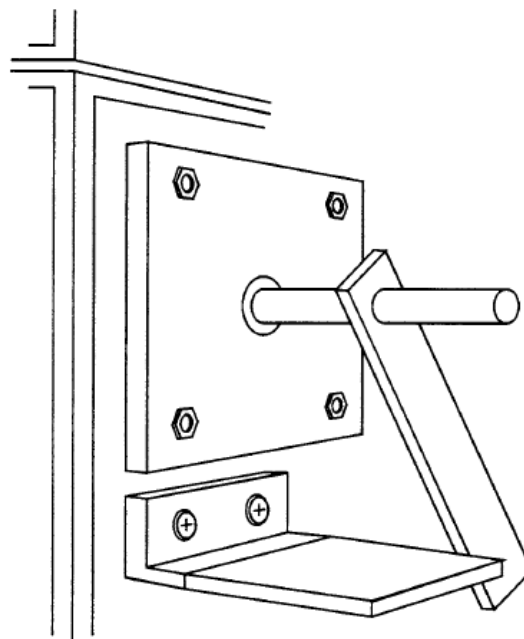


Figure M-8. Propane burner stop

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 inches (± 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).

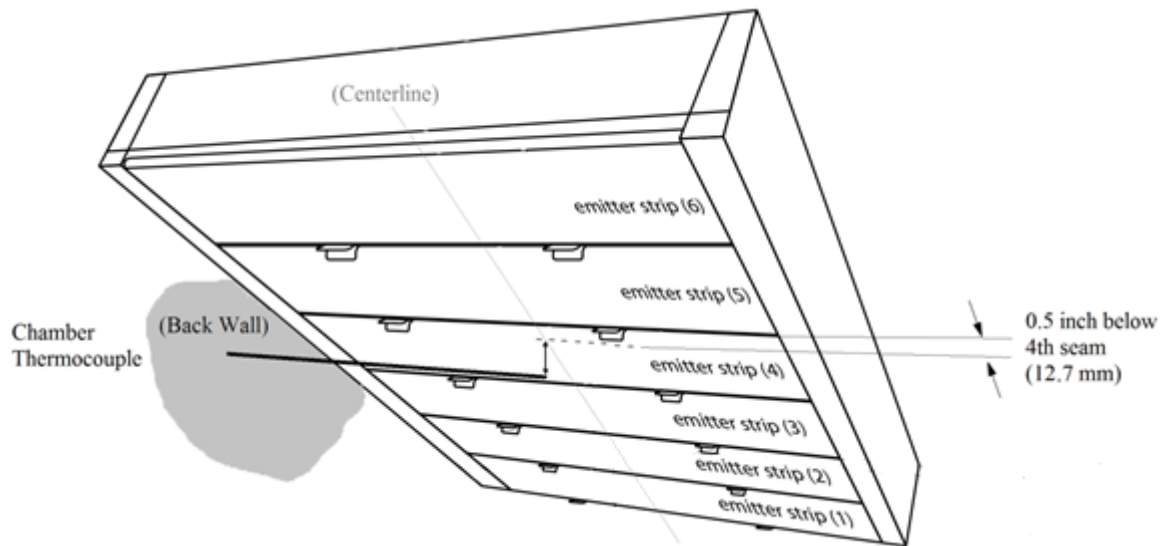


Figure M-9. Thermocouple placement

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 minimum 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 1.5625 inches (39.7 mm) 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).

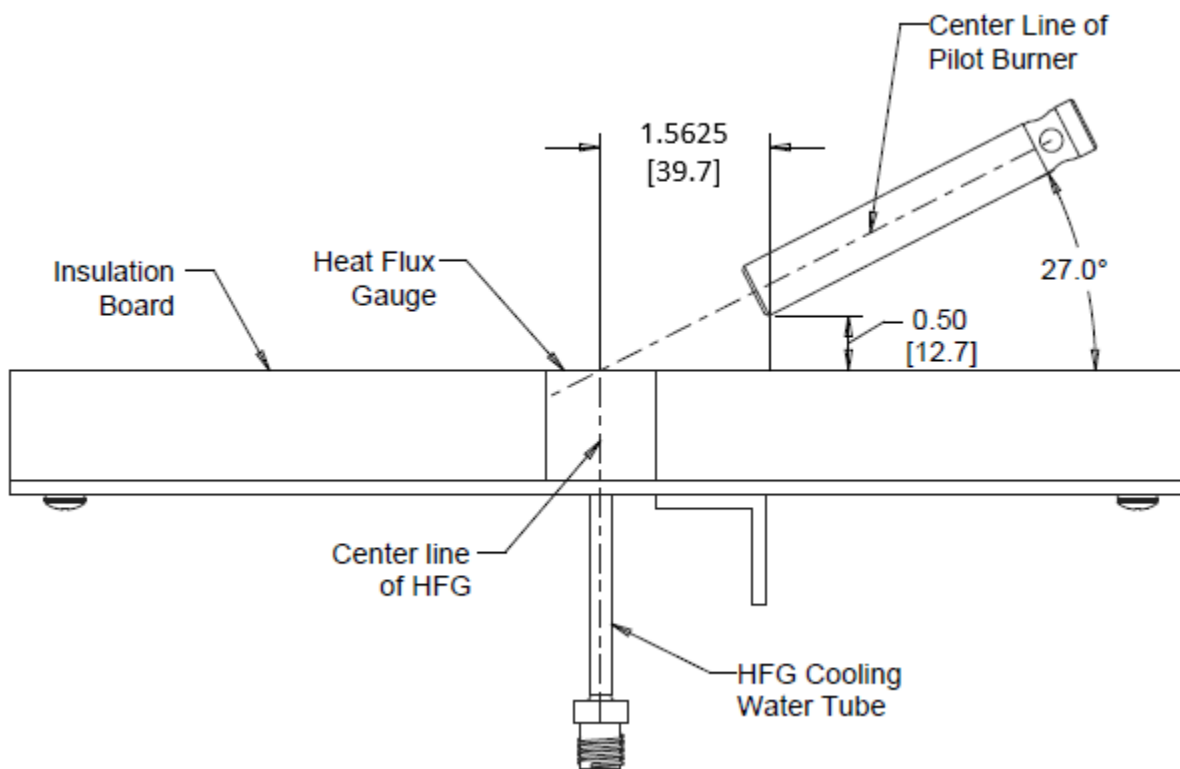


Figure M-10. HFG/Pilot burner alignment (side view)

Note: It is acceptable for the HFG fixture to accommodate up to a 1-inch-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 $1.0625 (\pm 0.0625)$ 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.

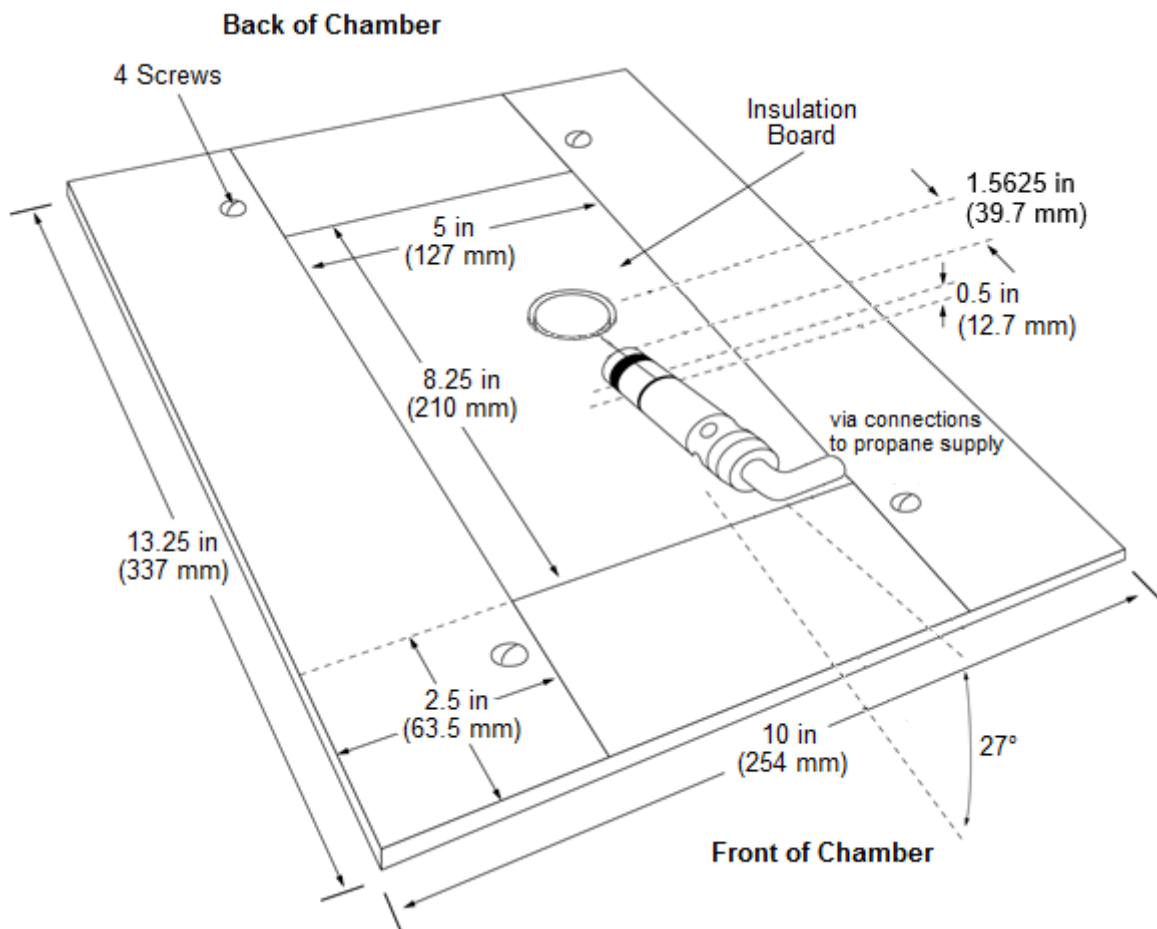


Figure M-11. HFG holder with one hole

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% of the reading. If a voltmeter is used, it requires a resolution of 0.01 mV and an accuracy of 0.3%.

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.