

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 (152.4 by 304.8 mm) coupon. A ~~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 ~~after 30 seconds~~, and the test is allowed to continue until all material combustion has ceased. The length of time is recorded from when the pilot flame is translated away from the sample to when combustion is ceased. The sample is removed from the test frame, and a posttest burn-length measurement is made. The burn length and after flame time are the only parameters used to determine passing or failing. A general view of the test chamber is displayed in figure N-1.

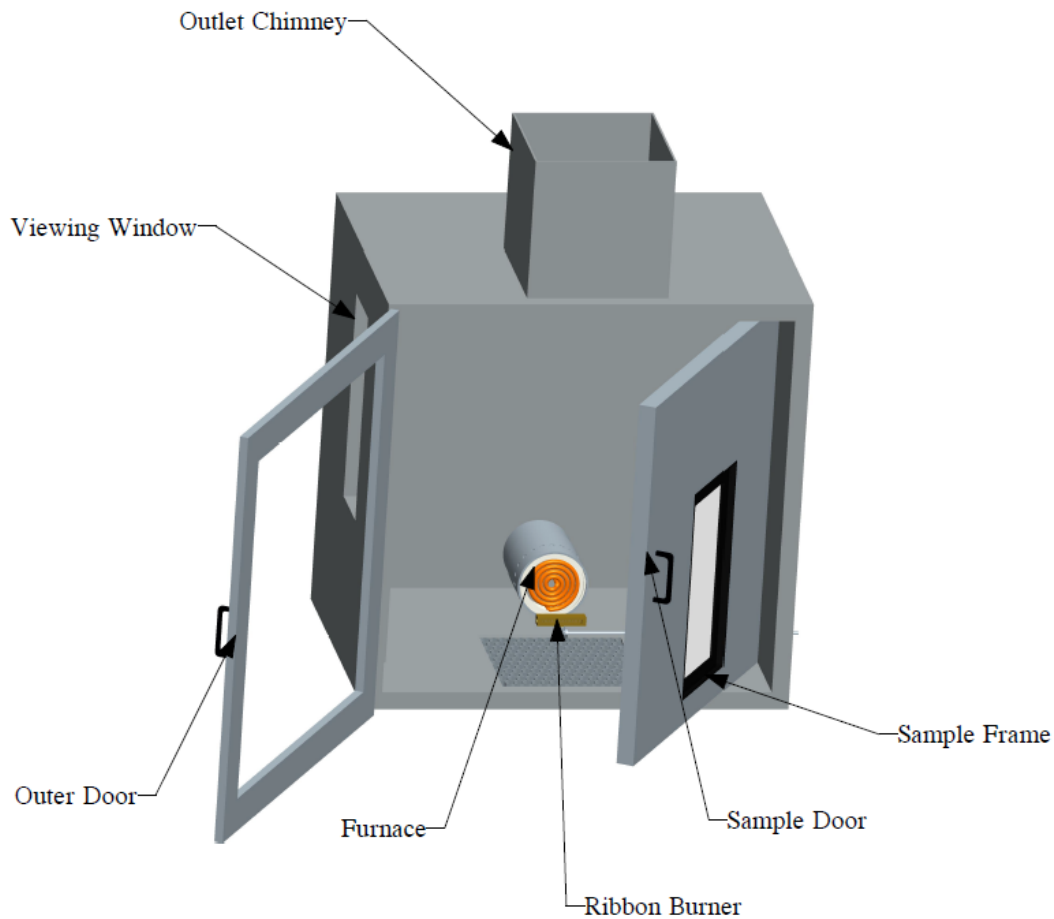


Figure N-1. Schematic of the VFP test apparatus

N.3. Test Apparatus Components

N.3.1 Test chamber

The inside dimensions of the box are 21.5 ± 0.6 inches (546.1 ± 15 mm) wide, 21.5 ± 0.6 inches (546.1 ± 15 mm) high, and 17 ± 0.6 inches (431.8 ± 15 mm) 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 sample is held in the internal door and the location of the “sample face” is depicted in Figure N-2. 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, which have a total combined surface area maximum of 144 in^2 (929 cm^2).

N.3.2 Exhaust and Inlet

The chamber exhaust chimney is constructed from 0.0625-inch (1.6 mm) thickness steel sheet metal on the inner wall of the chamber (Figure N-2). The exhaust cross-section inner dimensions are 8 inches (203.2 mm) long and 8 inches (203.2 mm) wide with tolerances of ± 0.25 inches (6.35 mm). The chimney exhaust height measures 8.5 inches (215.9 mm) tall, from the inner chamber ceiling wall to the top of the chimney, with tolerances of ± 0.6 inches (15.24 mm). This is placed as an outlet for the smoke and gasses to escape from the inner chamber. The VFP chamber exhaust must be decoupled from the lab's exhaust hood to prevent external influences on the chamber's air flow.

On the inside floor of the chamber directly aligned with the location of the exhaust, the air inlet will also be 8 inches long and 8 ± 0.25 inches (203.2 ± 6.35 mm) wide, 64 ± 3 in² (412.9 ± 19 cm²). 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 top surface of the perforated stainless-steel sheet will sit flush with the horizontal plane of the inner chamber floor within ± 0.1875 inches (± 4.76 mm).

The aluminum honeycomb is 0.75 ± 0.008 -inch (19.1 ± 0.2 mm) thick with a 0.5-inch (12.7 mm) cell size.

The perforated stainless-steel sheet that rests on top of the honeycomb is 0.024-inch (0.6 mm) thick, 24 gauge, has a 0.045-inch (1.1 mm) hole diameter, 37 percent open area, and 0.066 inches (1.7 mm) hole center to center.

N.3.3 Machine Height to Worktable/Bench

The bottom of the honeycomb will be 1.5 ± 0.125 inches (38.1 ± 3 mm) above the table/bench top the machine rests on. This is shown in Figure N-3.

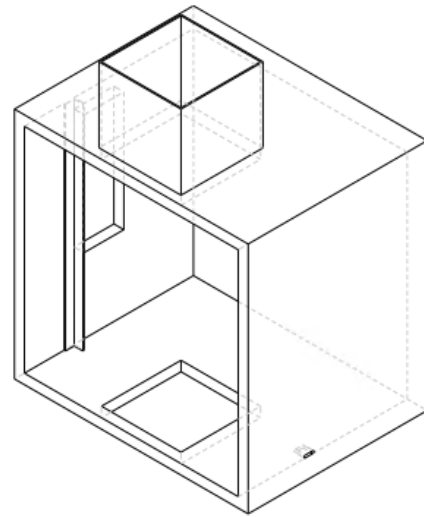
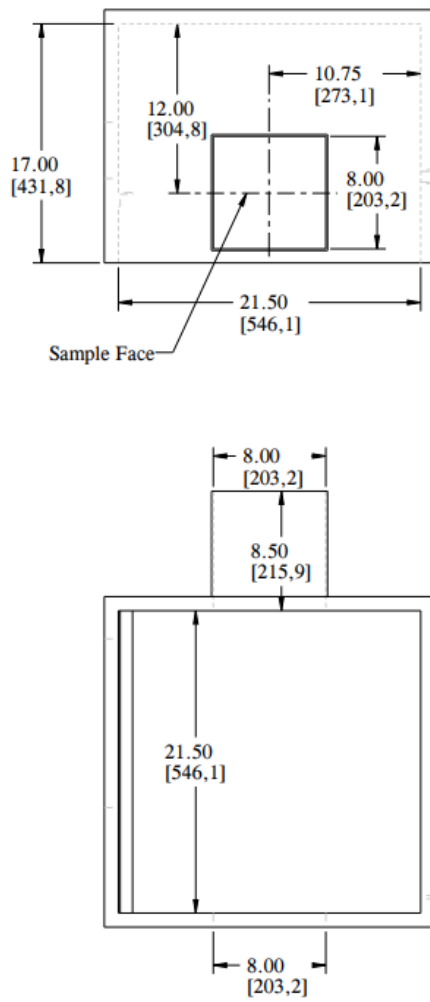


Figure N-2. Dimensioned Drawing of the Chamber Frame

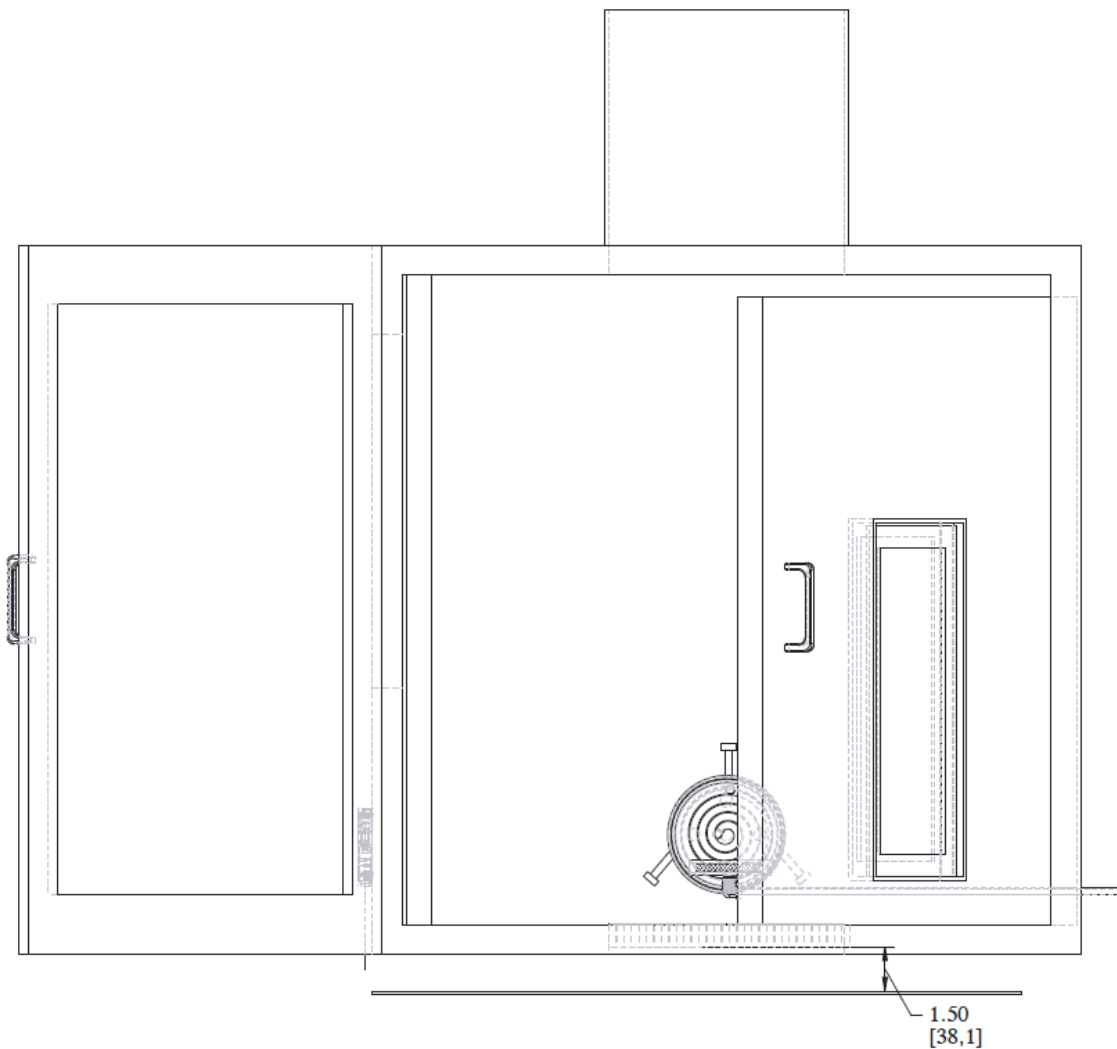


Figure N-3. Height of Chamber from Honeycomb Base to Worktable/Bench

N.3.4 Sample Door

The inner sample door is displayed in Figure N-4 with tolerances of ± 0.0625 inch (1.6 mm). 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.

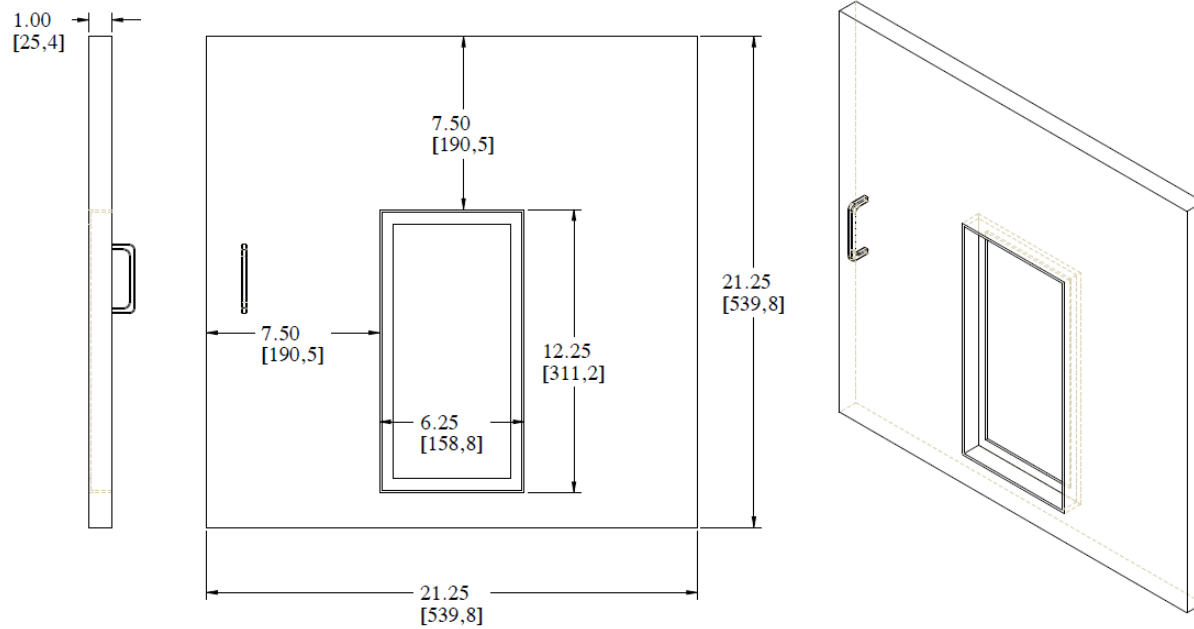


Figure N-4. Dimensioned drawing of the sample door

N.3.5 Outer Door

An outer door encloses the unit and protects the user during testing. This is shown in figure N-5. It has a frame with a sturdy glass embedded inside to view the sample door while testing.

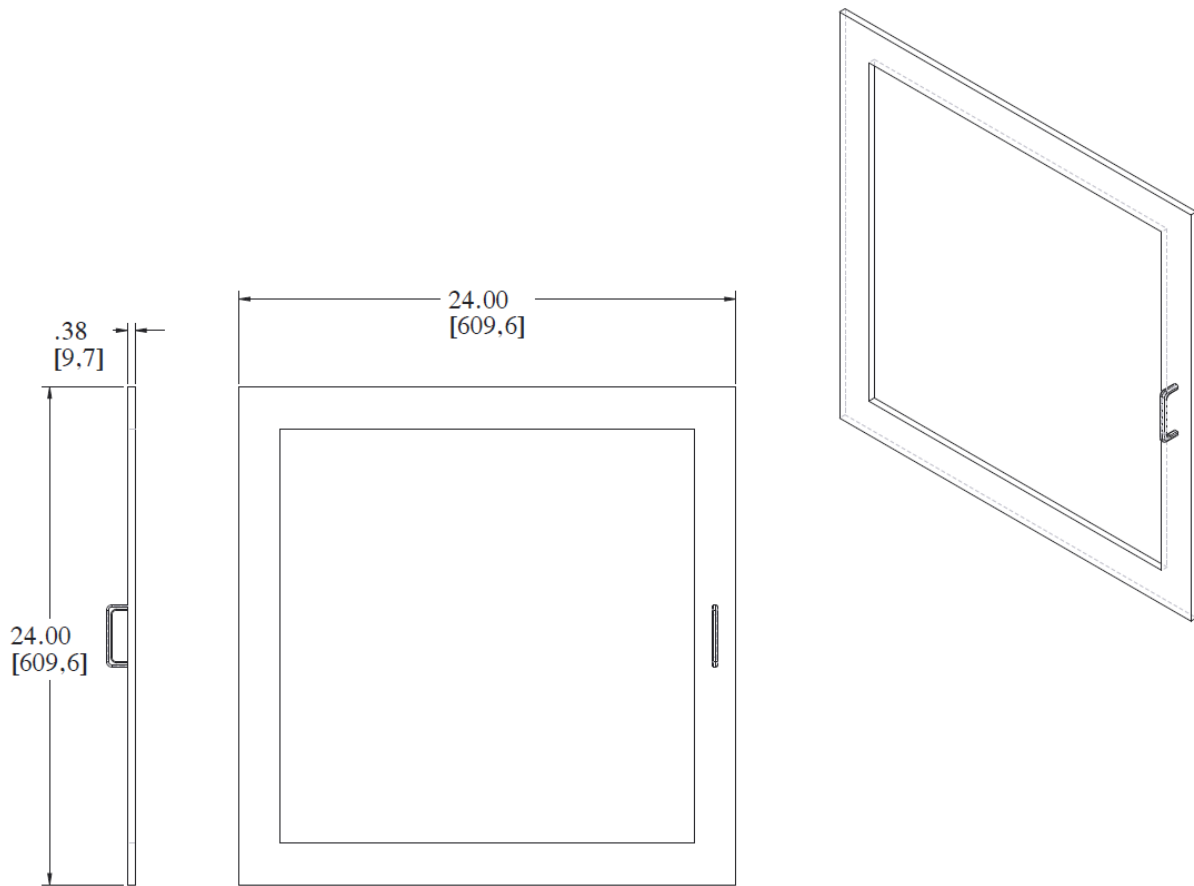


Figure N-5. Typical drawing of the outer chamber door

N.3.6 Thermocouple

A Type K 1/16-inch (1.6mm) diameter stainless steel thermocouple is placed on the outer left- or right-hand side of the chamber to monitor ambient air temperatures entering the machine. The thermocouple is depicted in Figure B3-3 and described in B3.3.2.6.

N.3.7 Sample Tray

The sample tray is displayed in Figure N-6. It is constructed from 0.125-inch (3.1 mm) thick, 1-inch (25.4 mm) angle steel. The front facing opening is enlarged by cutting the angle steel down to 0.625 inch (15.9 mm) to allow for a larger exposed sample surface area. The inside of the sample frame at the right angle is ground 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.

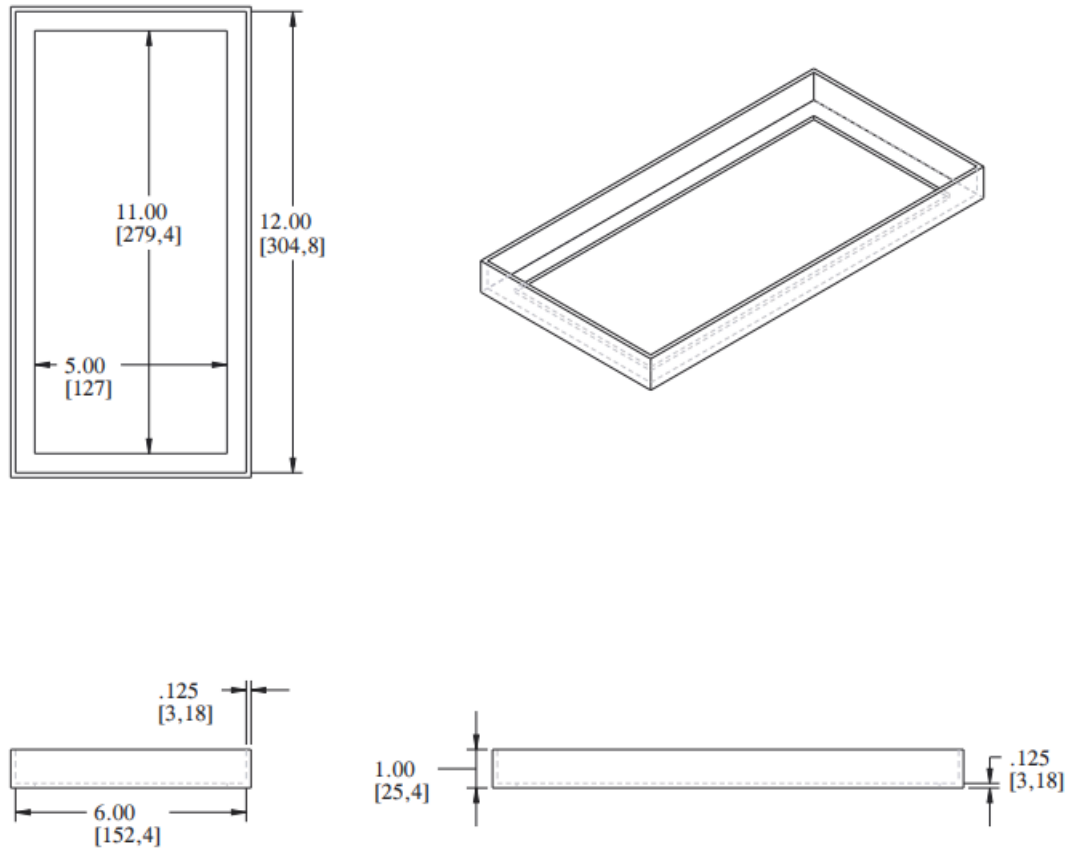


Figure N-6. Dimensioned drawing of the sample tray

N.3.8 Sample Retaining Frame

The sample retaining frame is displayed in Figure N-7. It is constructed from 0.125-inch (3.1 mm)-thick steel. It is placed behind some test samples during a test to provide uniform pressure on the back of the sample.

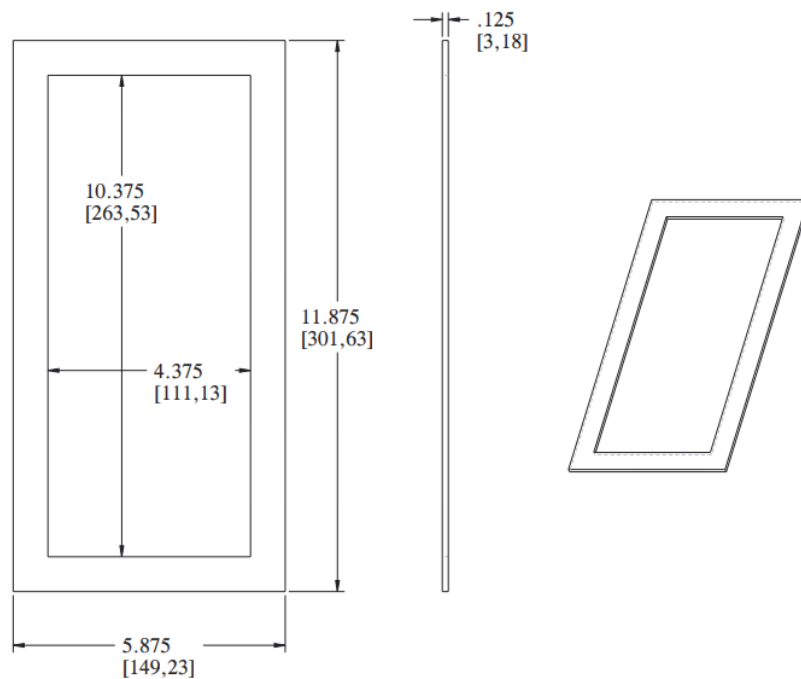


Figure N-7. Dimensioned drawing of the sample retaining frame

N.3.9 Ceramic Fiberboard Blank Panel

A diagram of the ceramic fiberboard blank panel is displayed in Figure N-8. This is placed inside the sample tray only to reduce heat loss during warmup and extended **time between sample sets beyond the user immediately changing to the next sample in the test series.** This board has a thermal conductivity of 0.832 Btu·in/hr·ft²·°F (0.12 W/mK) at 401 °F (205 °C).

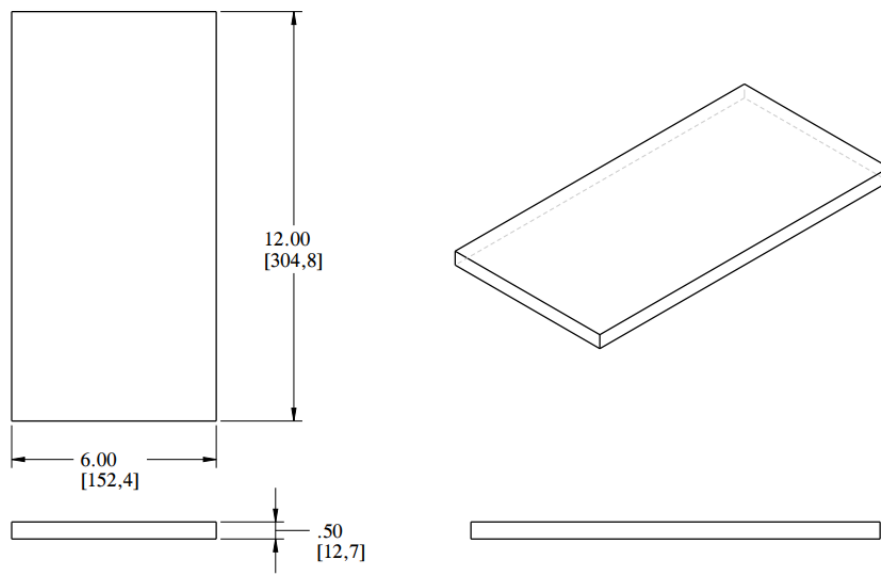


Figure N-8. Dimensioned drawing of ceramic fiberboard blank panel

N.3.10 Sample Holders

N.3.10.1 Composite Samples

The composite sample will be placed into the sample tray and the sample retaining frame will be placed behind the sample so that the sample is between the retaining frame and the radiant heater.

N.3.10.2 Duct Samples

The duct sample will be placed into the sample tray vertically and the sample retaining frame will be placed behind the flat, round, or half duct material to secure in place.

N.3.10.3 Wire Insulation Samples

The sample holder will hold three wires vertically taught and 0.375 inch (9.5 mm) apart center-to-center. The center wire must be directly centered horizontally in the sample holder. A fiberboard of thickness 0.25 inches (6.4 mm) with a thermal conductivity of 0.832 Btu·in/hr·ft²·°F (0.12 W/mK) at 401 °F (205 °C) will be placed behind the set of wires to be tested.

N.3.10.4 Wire Sleeve Samples

Wire sleeving samples and ribbon cables will be placed into the sample tray oriented vertically and centered with the ceramic fiberboard blank panel placed behind it to secure it in place. The 14 ± 2 inch (355 ± 51 mm) length of the sleeving material assists in properly securing the sample in place shown in Figure N-9.

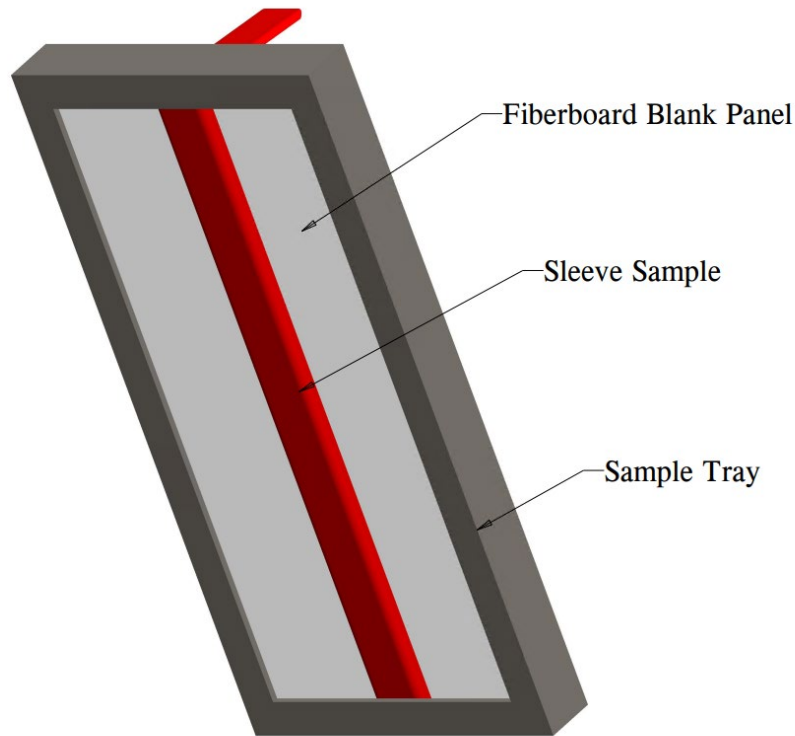


Figure N-9 – Placement of sleeving material in sample holder to be tested

N.3.11 Radiant Heat Furnace

The radiant furnace is displayed in Figure N-10. It is a similar furnace to that specified in the [smoke-density test called out in the Fire Test Handbook Chapter D4 \(previously Chapter 6\)](#), and the [evacuation slide test called out in TSO C69c and the Fire Test Handbook Chapter A2](#). The diameter of the heated element is nominally 3 inches (76.2 mm). The front half of the furnace housing is constructed with a diameter of 4 inches (101.6 mm). Ceramic insulating rings are placed inside the housing to fill the space between the heating coil and the housing. [The radiant heater compatibility beyond the physical construction listed in this section will be confirmed by following section N.3.16 in this chapter as well as the process described in section B3.6.](#)

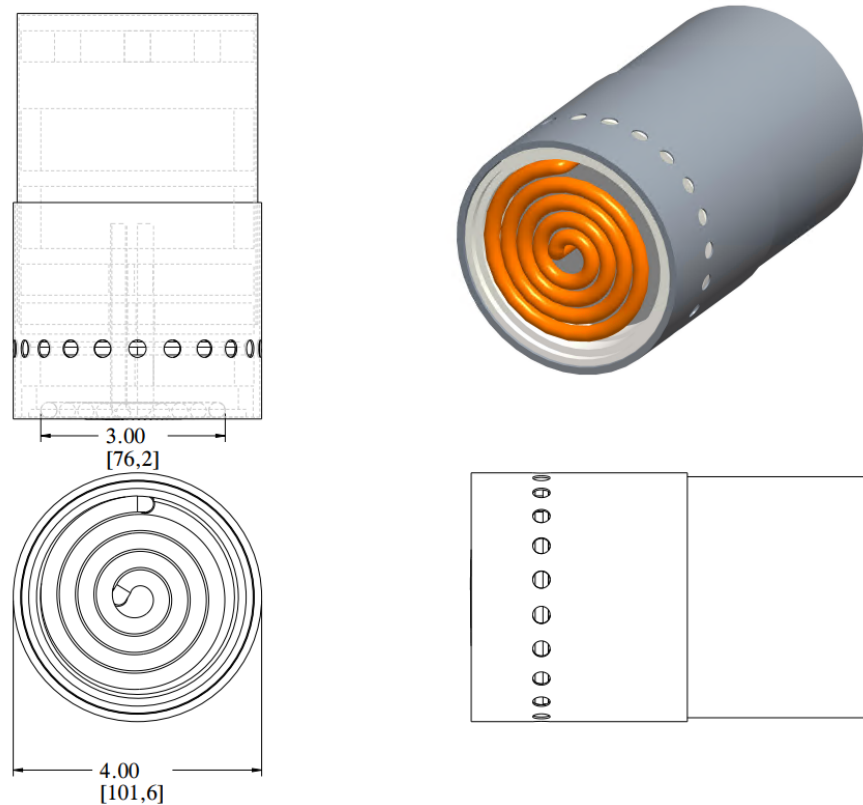


Figure N-10. Typical drawing of the radiant furnace

N.3.12 Furnace Mounting Assembly

The furnace mounting assembly is displayed in Figure N-11. 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 1.5 ± 0.1 inches (38.1 ± 2.5 mm) above the bottom of the sample frame. The centerline of the ribbon burner face is positioned 1.125 inches (28.6 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 (76.2 mm).

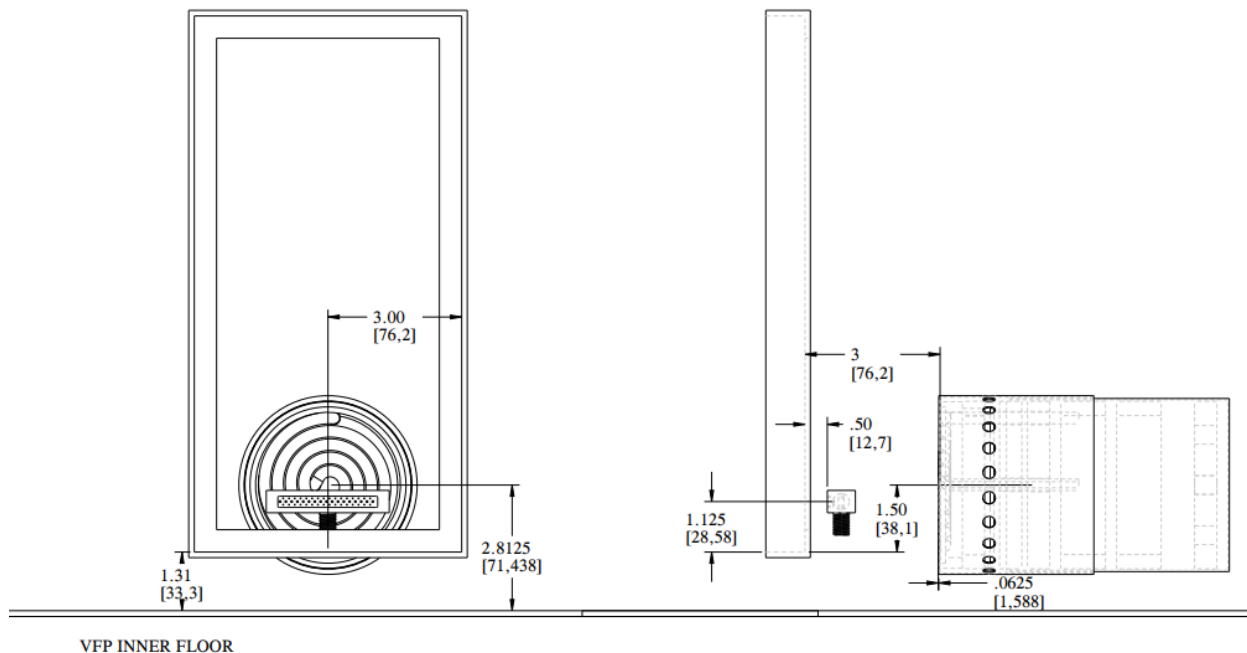


Figure N-11. Dimensioned drawing of the furnace mounting assembly

N.3.13 Power Controller

Control and monitor the radiant furnace so that the power or temperature control on the heater to the element maintains a heat flux reading of 1.59 ± 0.04 Btu/ft²sec (1.8 ± 0.05 Watts/cm²) for a 5-minute average.

N.3.14 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.3.15 Methane and Air Flow Controllers

The mass-flow controllers used should monitor values under 1 LPM of fuel and 5 LPM of air. The methane and air must be accurately measured to ensure proper operation of the ribbon burner. The methane to air ratio is 0.66/3.6 SLPM when the mass flow controllers are calibrated to a temperature and pressure condition of 77 °F (25 °C) and 14.7 PSIA (101.325 KPa). The gas pressure is driven by the requirements of the mass-flow controller's manufacturer. Condensation must be prevented through the lines leading to the mass flow controllers to preserve calibration

and function. The supplied air shall be clean and free of non-condensing water vapor ($\leq 65\%$ RH), oil mist, and foreign particles.

N.3.16 Heat Flux and Heater Calibration

A heat flux gauge will be used to calibrate the radiant heat source. The gauge will be inserted into the sample holder and through a 0.5-inch-thick (12.7 mm) ceramic fiberboard, with a thermal conductivity of $0.832 \text{ Btu}\cdot\text{in}/\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}$ ($0.12 \text{ W}/\text{mK}$) at 401°F (205°C), such that the face of the gauge and surface of the board are flush. A holding fixture may be placed behind the fiberboard to keep the heat flux gauge in place. The board is 6 by 12 ± 0.125 inches (152.4 ± 0.3 by 304.8 ± 0.3 mm). The heat flux gauge must be in accordance with Appendix H in the Fire Test Handbook.

N.3.16.1 Heat Flux Gauge Placement for Confirming Radiant Heat Gradient Upon Sample

If the radiant heater is replaced, physically moved in the chamber, or every six months if the heater has not been adjusted sooner, the heat flux gradient upon the sample must be measured. This will consist of multiple fiberboards so that each measurement taken is with a board with one single hole placed in it. One board cannot be used if it has more than one hole cut in it although the boards can be turned or flipped to be utilized for multiple locations as long as the side facing the heater has no extra materials added onto that side. The location of these holes for the heat flux gauge in each individual board is shown in Figures N-13 and N-14. The required heat flux for each of these locations is shown in Figure N-15 and to be within $\pm 0.04 \text{ Btu}/\text{ft}^2\text{sec}$ ($\pm 0.05 \text{ W}/\text{cm}^2$).

N.3.16.2 Heat Flux Gauge Placement Before Testing Material

For regular use of the machine before testing materials, the heat flux gauge is to be used to calibrate the heater for use. An image of the gauge in this orientation is shown in Figure N-12. The input power shall be adjusted to achieve a 5-minute average heat flux of $1.59 \pm 0.04 \text{ Btu}/\text{ft}^2\text{sec}$ ($1.8 \pm 0.05 \text{ Watts}/\text{cm}^2$). This procedure is explained in B3.7. This set point will then be non-adjustable for the duration of testing after calibration is complete.

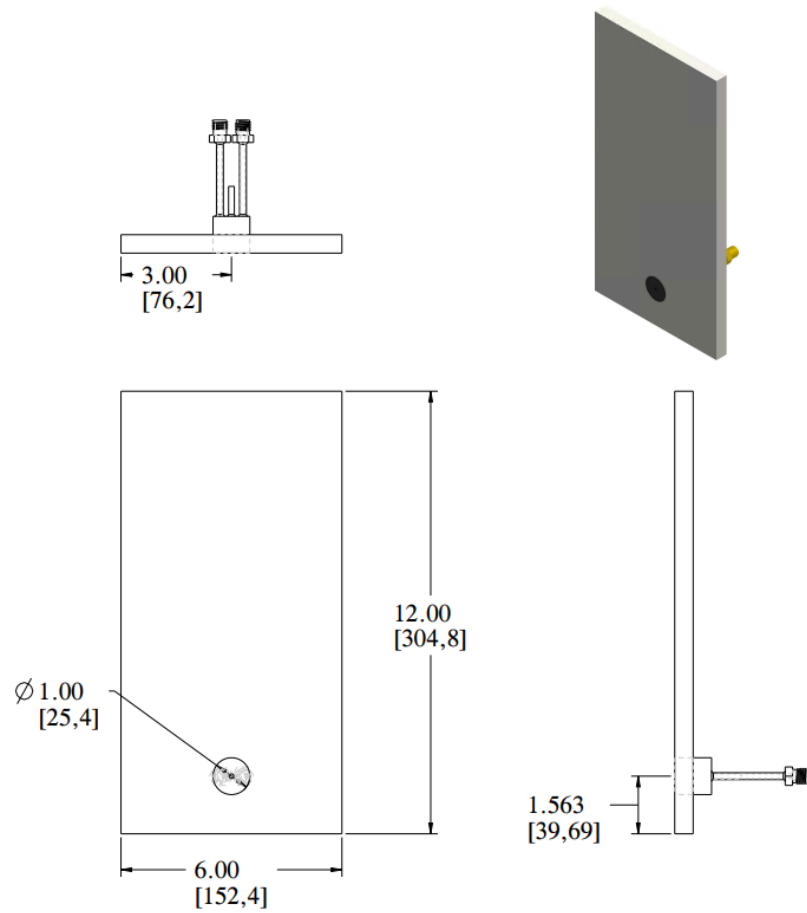
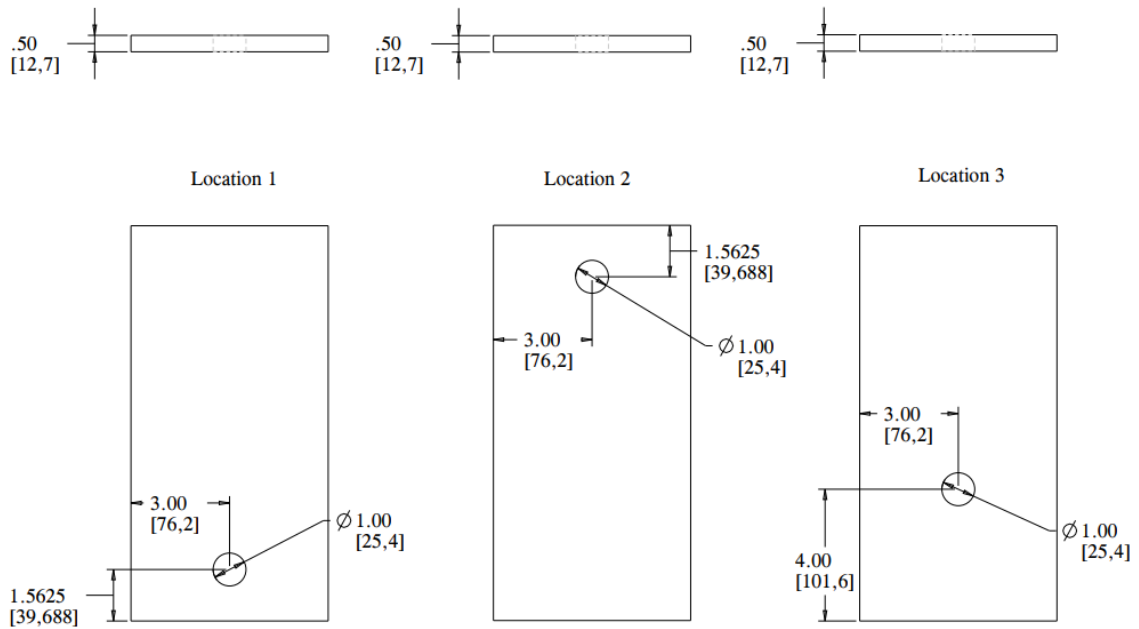
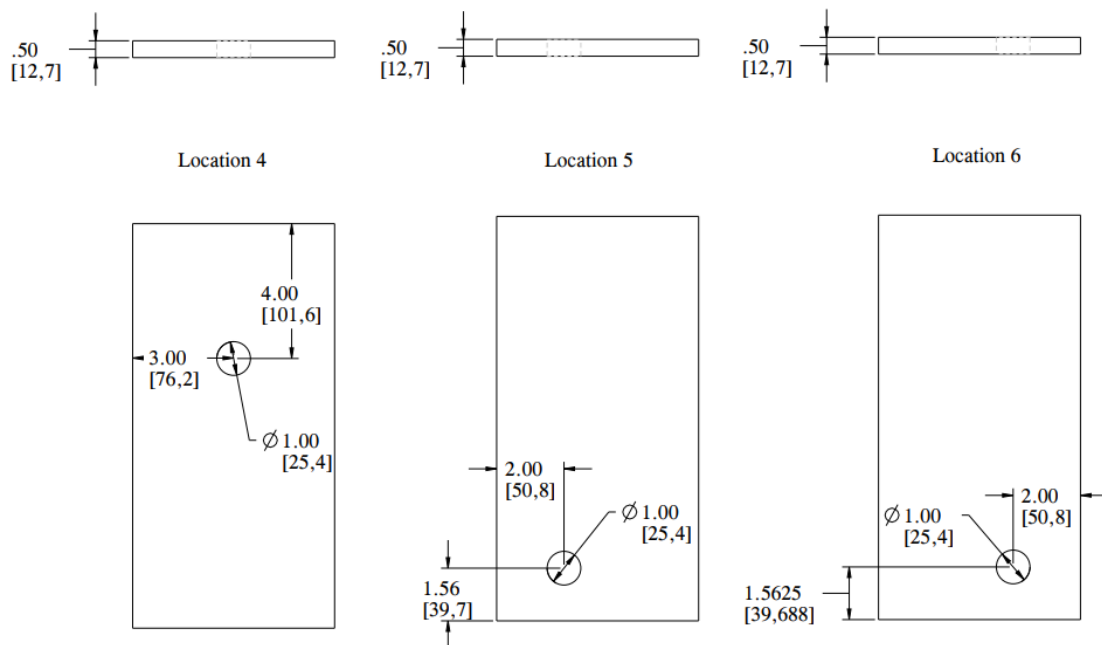


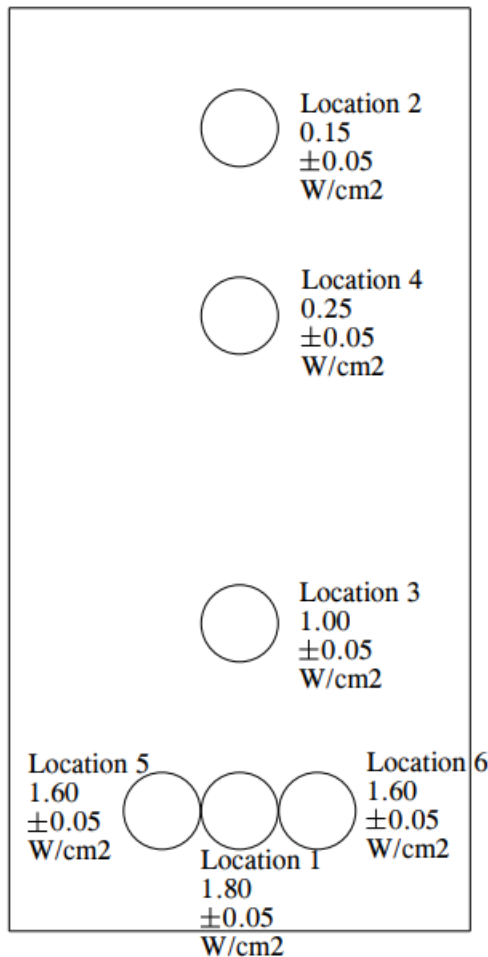
Figure N-12. Heat Flux Gauge Mounting Fixture Before Testing Material



N-13. Ceramic Fiberboards Depicting Locations for Measuring Heat Flux Gradient Upon the Sample Face



N-14. Ceramic Fiberboards Depicting Further Locations for Measuring Heat Flux Gradient Upon the Sample Face



N-15. Measurement Ranges and Locations for Heat Flux Gradient Upon the Sample Face for Locations Depicted in N-13 and N-14

N.3.17 Ribbon Burner

The ribbon burner is displayed in figure N-16. It is a uniform-flame uni-directional ribbon burner constructed of brass. The flame is directed horizontally from three rows of gas holes, 34 total small holes and 18 larger holes. The burner may have a clean-out port on the end for ease of cleaning and maintenance. The dimensions and construction of the build of the ribbon burner are displayed in Figures N-17, N-18, and N-19.

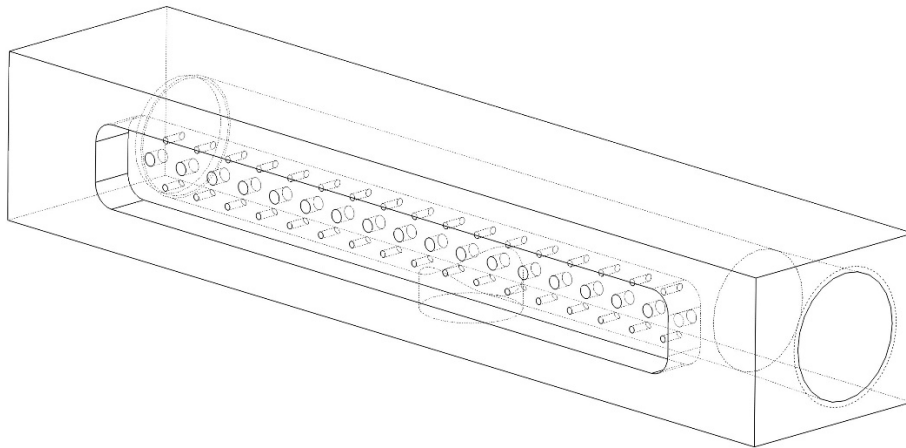


Figure N-16. Body of the Ribbon Burner Construction

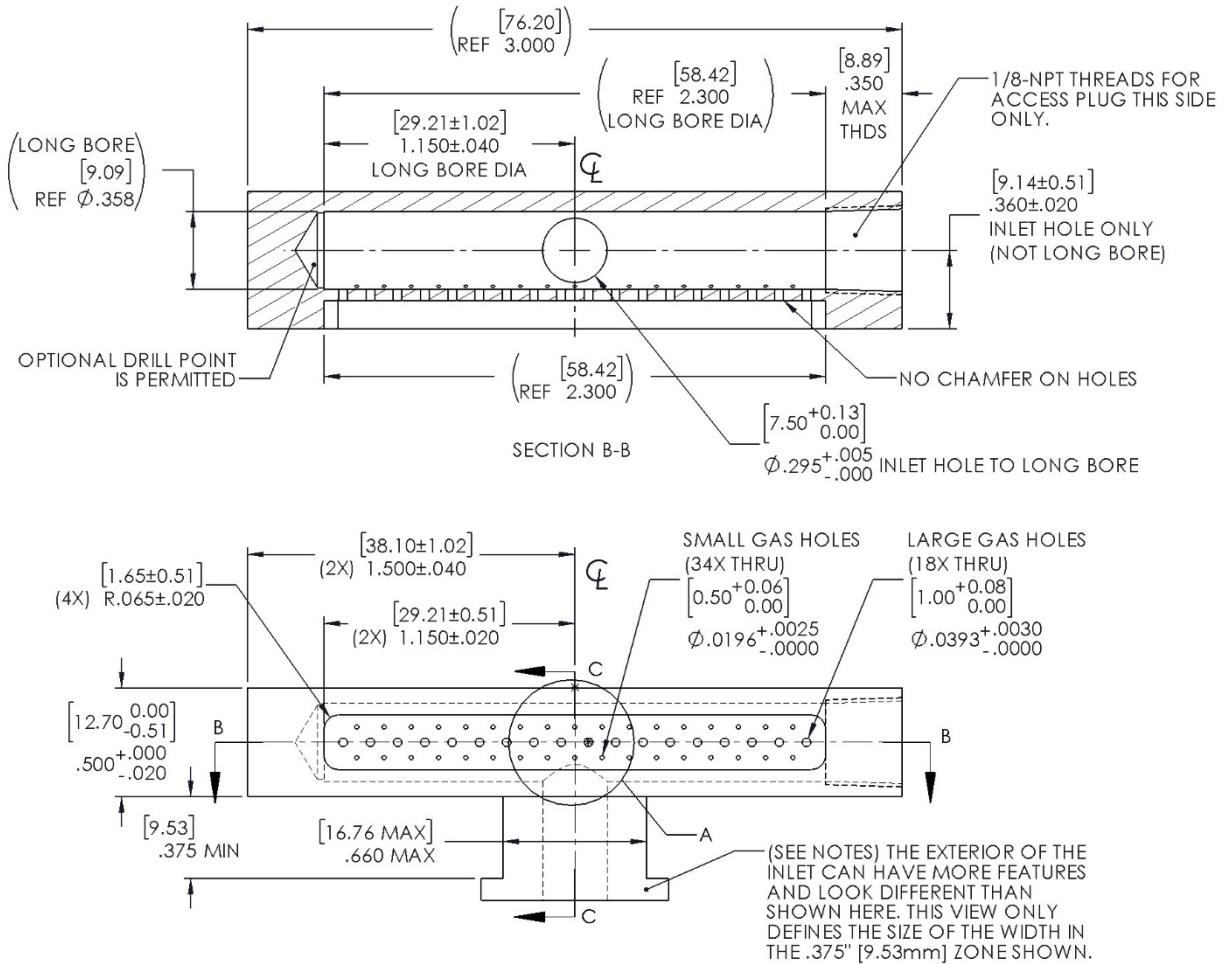


Figure N-17. Construction Details of Ribbon Burner

Note. The gas inlet fixture leading to the body of the ribbon burner may have different variations as to how it is held as long as the width shown is a maximum of 0.660 inches (16.76 mm).

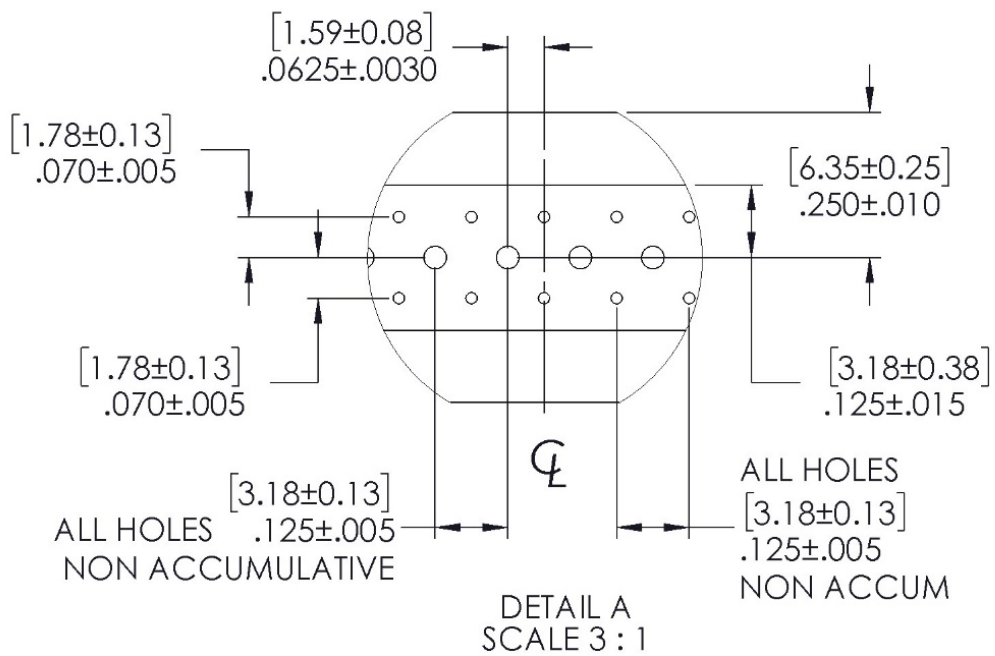


Figure N-18. Detailed Drawing Section A of Ribbon Burner Fuel Holes and Spacing

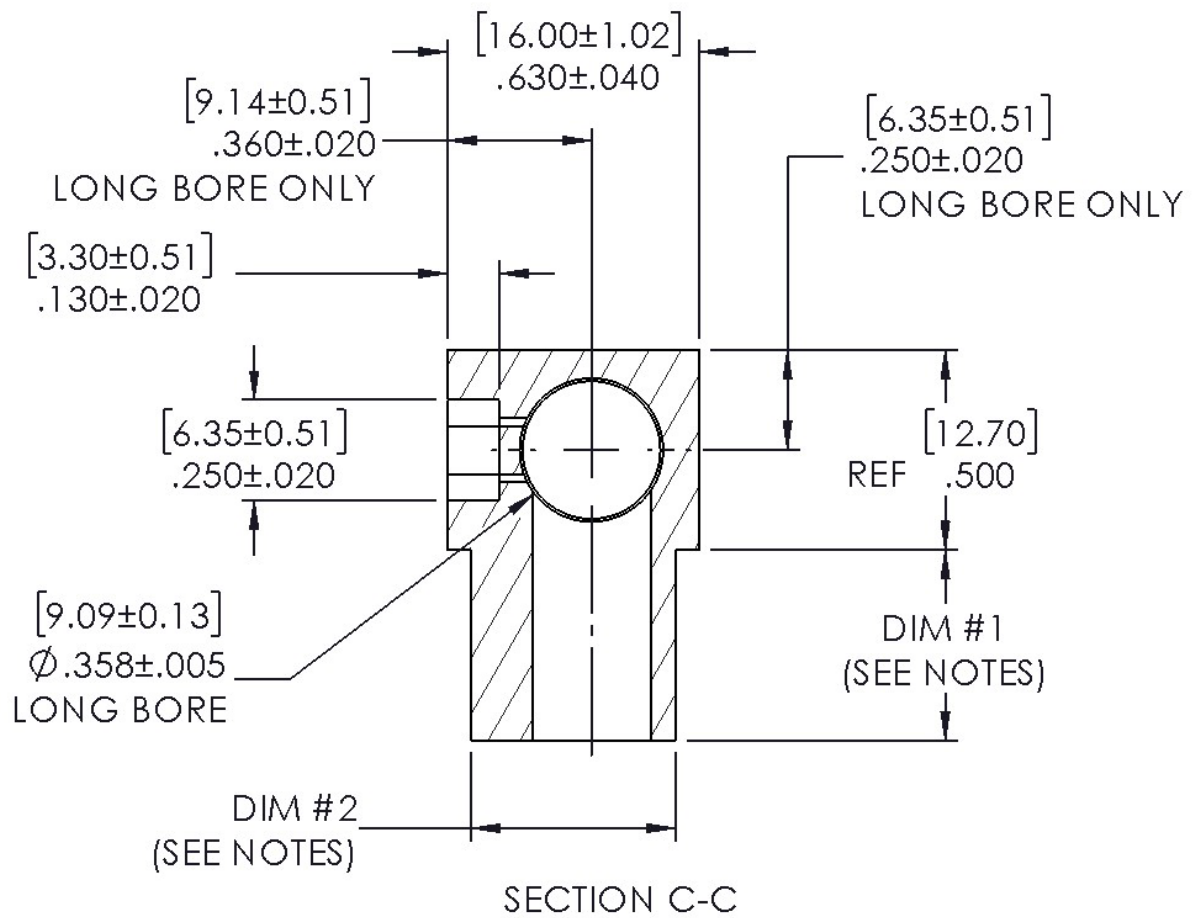


Figure N-19. Detailed Drawing Section C of Ribbon Burner Internal Side View

Note. Dimensions #1 and #2 are undefined as the shape in which the gas inlet into the ribbon burner body is undefined yet built within few parameters. It must be built so that the height of the flame upon the sample face is as defined in this chapter. The gas inlet must be designed so that the base of the burner is spaced at a gap of a minimum of 0.25 inch (6.35 mm) from the top of the perforated sheet in the floor of the chamber.

N.4 Typical Test Apparatus Configuration

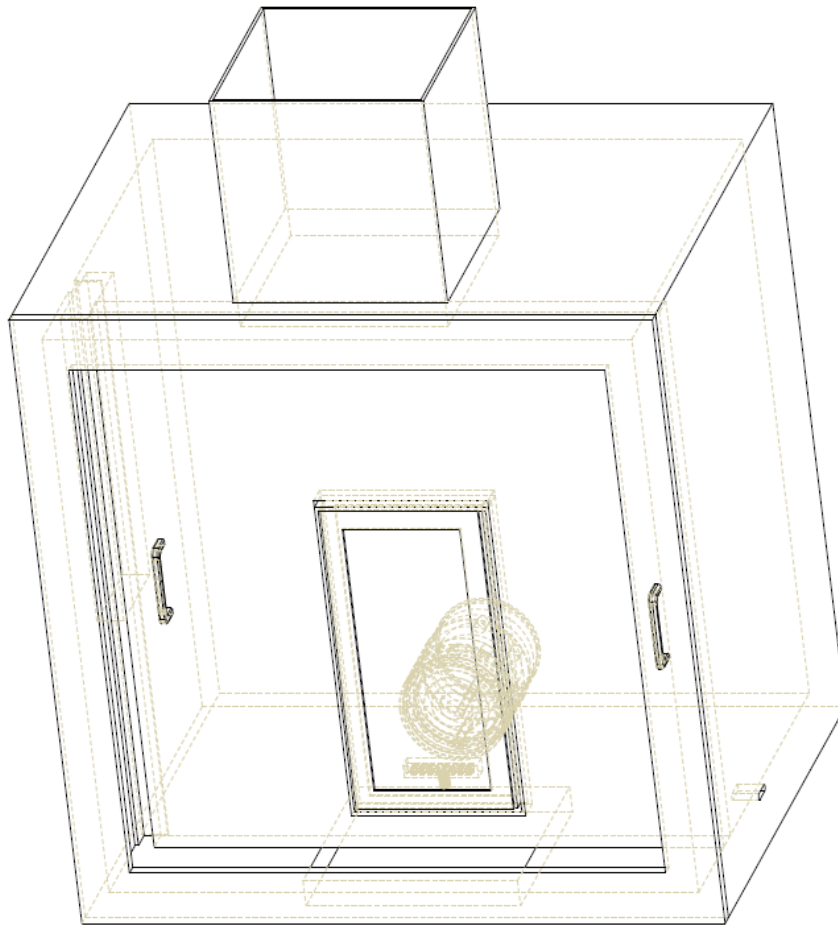


Figure N-20. Typical VFP Test apparatus with both inner and outer doors closed

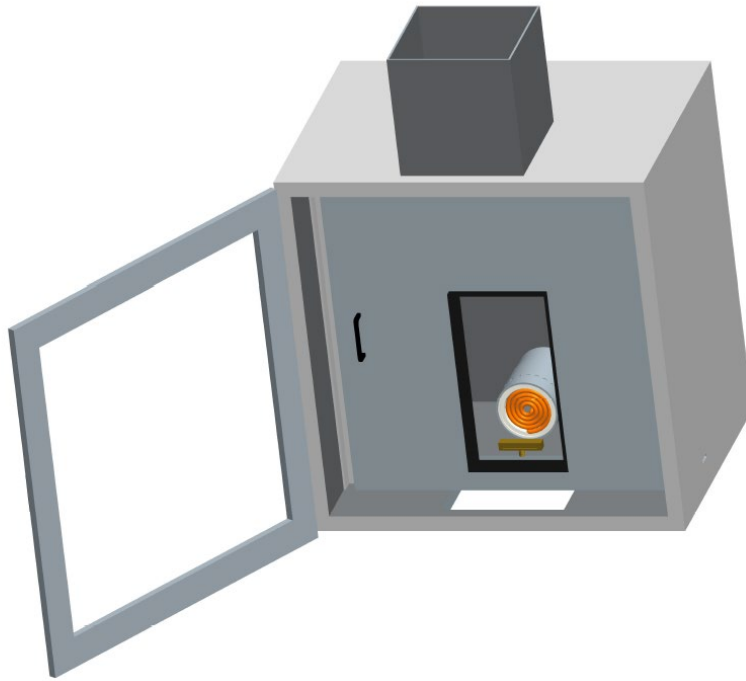


Figure N-21. Typical VFP Test apparatus with sample door closed and no sample in place

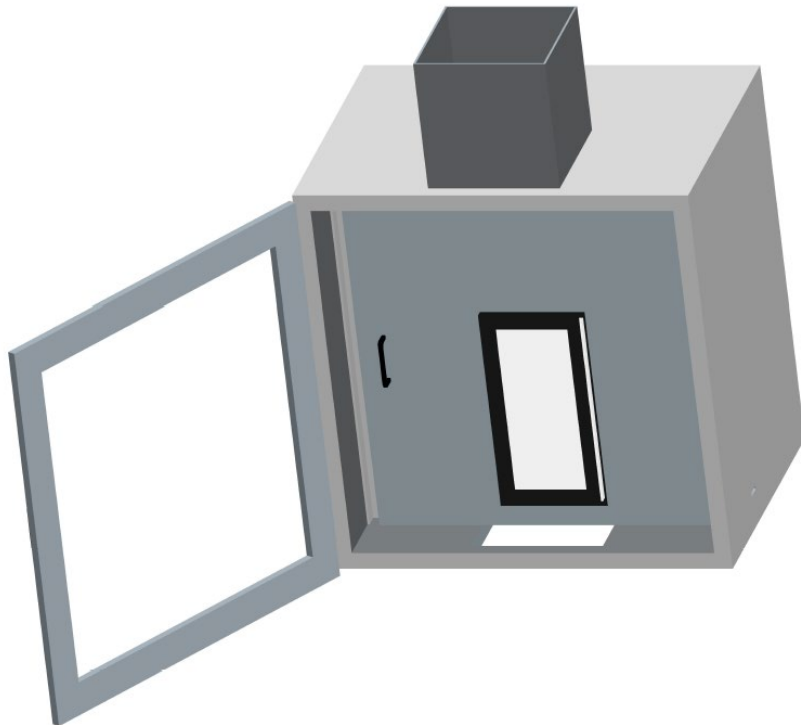


Figure N-22. Typical VFP Test apparatus with sample door closed with sample in place