



# Standard Test Method for Critical Radiant Flux of Exposed Attic Floor Insulation Using a Radiant Heat Energy Source<sup>1</sup>

This standard is issued under the fixed designation E 970; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This fire-test-response standard describes a procedure for measuring the critical radiant flux of exposed attic floor insulation subjected to a flaming ignition source in a graded radiant heat energy environment in a test chamber. The specimen is any attic floor insulation. This test method is not applicable to those insulations that melt or shrink away when exposed to the radiant heat energy environment or the pilot burner.

1.2 This fire-test-response standard measures the critical radiant flux at the point at which the flame advances the farthest. It provides a basis for estimating one aspect of fire exposure behavior for exposed attic floor insulation. The imposed radiant flux simulates the thermal radiation levels likely to impinge on the floors of attics whose upper surfaces are heated by the sun through the roof or by flames from an incidental fire in the attic. This fire-test-response standard was developed to simulate an important fire exposure component of fires that develop in attics, but is not intended for use in estimating flame spread behavior of insulation installed other than on the attic floor.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.4 The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this standard.

1.5 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appro-*

*priate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

## 2. Referenced Documents

### 2.1 ASTM Standards:

C 665 Specification for Mineral Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing<sup>2</sup>

C 764 Specification for Mineral Fiber Loose-Fill Thermal Insulation<sup>2</sup>

E 84 Test Method for Surface Burning Characteristics of Building Materials<sup>3</sup>

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality of a Lot or Process<sup>4</sup>

E 176 Terminology Relating to Fire Standards<sup>3</sup>

E 631 Terminology of Building Constructions<sup>3</sup>

E 648 Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source<sup>3</sup>

### 2.2 Federal Specifications:

HH-I-515 Insulation Thermal (Loose Fill for Pneumatic or Poured Application), Cellulosic or Wood Fiber<sup>5</sup>

HH-I-521, Insulation Blankets, Thermal (Mineral Fiber, for Ambient Temperature)<sup>5</sup>

HH-I-1030 Insulation, Thermal (Mineral Fiber, for Pneumatic or Poured Application)<sup>5</sup>

## 3. Terminology

3.1 For definitions of terms used in this test method and associated with fire issues refer to the terminology contained in Terminology E 176.

### 3.2 Definition:

3.2.1 *attic, n*—an accessible enclosed space in a building immediately below the roof and wholly or partly within the roof framing.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.22 on Surface Burning.

Current edition approved July 10, 2000. Published August 2000. Originally published as E 970 – 83. Last previous edition E 970 – 98.

<sup>2</sup> Annual Book of ASTM Standards, Vol 04.06.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.07.

<sup>4</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>5</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.2.2 See Terminology E 631 for additional definitions of terms used in this test method.

3.3 Definitions of Terms Specific to This Standard:

3.3.1 *critical radiant flux, n*—the level of incident radiant heat energy on the attic floor insulation system at the most distant flame-out point. It is reported as  $W/cm^2$  (or  $Btu/ft^2 \cdot s$ ).

3.3.2 *radiant flux profile, n*—the graph relating incident radiant heat energy on the specimen plane to distance from the point of initiation of flaming ignition, that is, 0 mm.

3.3.3 *total flux metre, n*—the instrument used to measure the level of radiant heat energy incident on the specimen plane at any point.

**4. Summary of Test Method**

4.1 A horizontally mounted insulation specimen is exposed to the heat from an air-gas radiant heat energy panel located above and inclined at  $30 \pm 5^\circ$  to the specimen. After a short preheat, the hottest end of the specimen is ignited with a small calibrated flame. The distance to the farthest advance of flaming is measured, converted to kilowatts per square meter from a previously prepared radiant flux profile graph, and reported as the critical radiant flux.

**5. Significance and Use**

5.1 This fire-test-response standard is designed to provide a basis for estimating one aspect of the fire exposure behavior to exposed insulation installed on the floors of building attics. The test environment is intended to simulate conditions that have been observed and defined in full-scale attic experiments.

5.2 The test is intended to be suitable for regulatory statutes, specification acceptance, design purposes, or development and research.

5.3 The fundamental assumption inherent in the test is that critical radiant flux is one measure of the surface burning characteristics of exposed insulation on floors or between joists of attics.

5.4 The test is applicable to attic floor insulation specimens that follow or simulate accepted installation practice.

5.5 In this procedure, the specimens are subjected to one or more specific sets of laboratory fire test exposure conditions. If different test conditions are substituted or the anticipated end-use conditions are changed, caution should be used to predict changes in the performance characteristics measured by or from this test. Therefore, the results are strictly valid only for the fire test exposure conditions described in this procedure.

5.5.1 If the test results obtained by this test method are to be considered in the total assessment of fire hazard in a building structure, then all pertinent established criteria for fire hazard assessment developed by Committee E-5 must be included in the consideration.

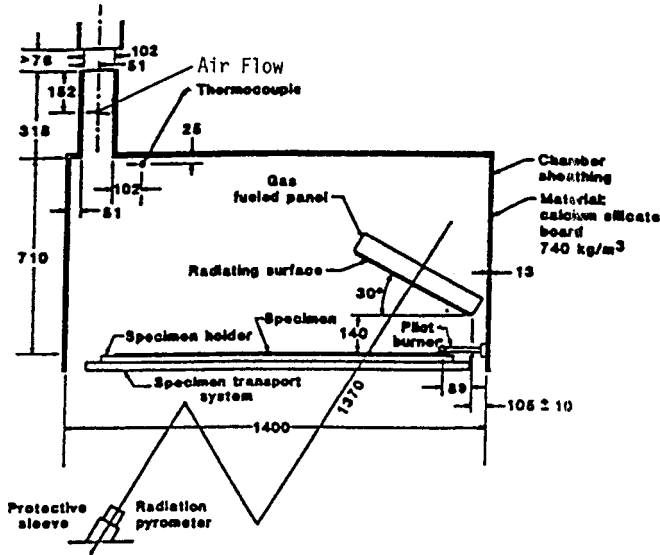
**6. Apparatus**

6.1 *Radiant Panel Test Chamber* (Fig. 1), located in a draft-protected laboratory that maintains a temperature from 10.0 to 26.7°C (50 to 80°F) and a relative humidity from 30 to 70 %.

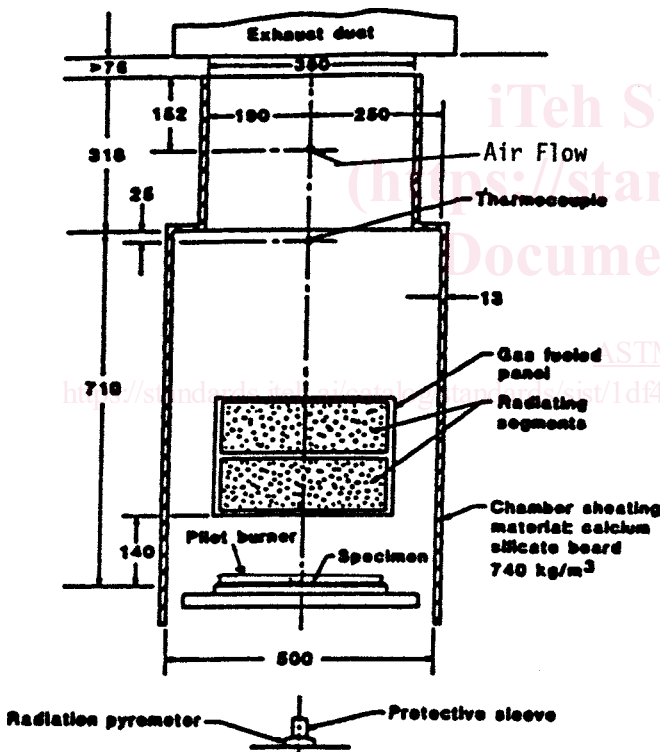
6.1.1 The radiant panel test chamber (Fig. 2 and Fig. 3) shall consist of an enclosure 1400 mm (55 in.) long by 500 mm



**FIG. 1 Radiant Test Panel Chamber**



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.  
 FIG. 2 Flooring Radiant Tester Schematic, Side Elevation



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 FIG. 3 Flooring Radiant Panel Tester Schematic Low Flux End, Elevation

(19½ in.) deep by 710 mm (28 in.) above the test specimen. The sides, ends, and top shall be of 13-mm (½-in.) calcium silicate, 740-kg/m<sup>3</sup>(46-lb/ft<sup>3</sup>) nominal density, insulating ma-

terial<sup>6</sup> with a thermal conductivity at 177°C (350°F) of 0.128 W/(m·K) (0.89 Btu · in./(h·ft<sup>2</sup>·°F)). One side shall be provided with an approximately 100 by 1100 mm (4 by 44 in.) draft-tight fire-resistant glass window so that the entire length of the test specimen is visible from outside the fire test chamber. On the same side and below the observation window is a door which, when open, allows the specimen platform to be moved out for mounting or removal of test specimens. At the low flux end of the chamber on the 500 mm side, a draft-tight fire-resistant window is permitted for additional observations.

6.1.2 The bottom of the test chamber shall consist of a sliding steel platform which has provisions for rigidly securing the test specimen holder in fixed and level position. The free, or air access, area around the platform shall be in the range from 0.2580 to 0.3225 m<sup>2</sup> (400 to 500 in.<sup>2</sup>).

6.1.3 When the flame front advance is to be measured, a metal scale marked with 10 mm intervals shall be installed on the back of the platform or on the back wall of the chamber.

6.1.4 The top of the chamber shall have an exhaust stack with interior dimensions of 102 ± 3 mm (4 ± 0.13 in.) wide by 380 ± 3 mm (15.00 ± 0.13 in.) deep by 318 ± 3 mm (12.50 ± 0.13 in.) high at the opposite end of the chamber from the radiant energy source.

6.2 *Radiant Heat Energy Source*, a panel of porous material mounted in a cast iron or steel frame, with a radiation surface of 305 by 457 mm (12 by 18 in.). It shall be capable of operating at temperatures up to 816°C (1500°F). The panel fuel system shall consist of a venturi-type aspirator for mixing gas<sup>7</sup> and air at approximately atmospheric pressure, a clean dry air supply capable of providing 28.3 m<sup>3</sup>/h (1000 ft<sup>3</sup>/h) at standard temperature and pressure at 76 mm (3.0 in.) of water, and suitable instrumentation for monitoring and controlling the flow of fuel to the panel.

6.2.1 The radiant heat energy panel is mounted in the chamber at 30 ± 5° to the horizontal specimen plane. The radiant energy panel angle shall be adjusted to obtain the flux profile within the limits specified in accordance with 10.6. The horizontal distance from the 0 mark on the specimen fixture to the bottom edge (projected) of the radiating surface of the panel is 89 ± 3 mm (3.5 ± 0.13 in.). The panel-to-specimen vertical distance is 140 ± 3 mm (5.5 ± 0.13 in.) (Fig. 2).

6.2.2 *Radiation Pyrometer* for standardizing the thermal output of the panel, suitable for viewing a circular area 254 mm (10 in.) in diameter at a range of about 1.37 m (54 in.). It shall be calibrated over the 460 to 510°C (860 to 950°F) operating blackbody temperature range in accordance with the procedure described in Annex A1.

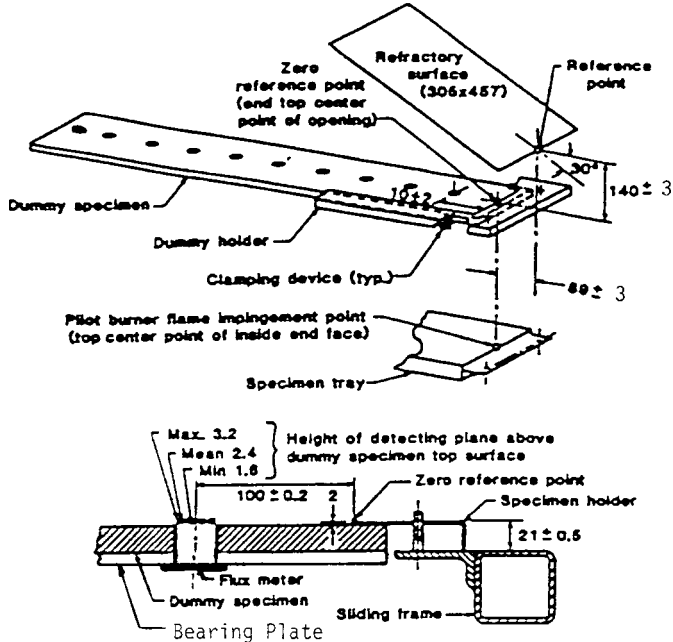
6.2.3 *Voltmeter*, high-impedance or potentiometric, with a suitable millivolt range shall be used to monitor the output of the radiation pyrometer described in 6.2.2.

6.3 *Dummy Specimen Holder* (Fig. 4 and Fig. 5), constructed from heat-resistant stainless steel (UNS N08330 (AISI

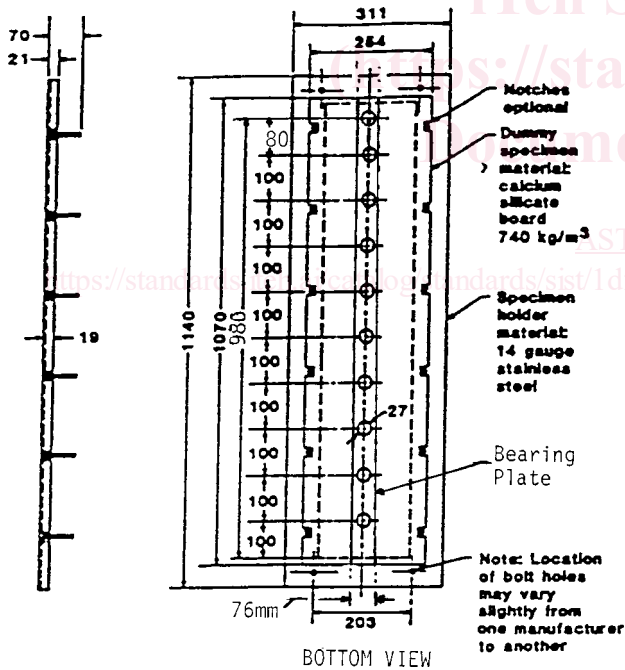
<sup>6</sup> Marinite I, manufactured by Manville Specialty Products Group, P.O. Box 5108, Denver, CO 80217, available through the local Manville distributor, has been found satisfactory.

<sup>7</sup> Gas used in this test method shall be either commercial grade propane having a heating value of approximately 83.1 MJ/m<sup>3</sup> (2500 Btu/ft<sup>3</sup>), or natural gas, or commercial grade methane having a minimum purity of 96 %.

BASIC COMPONENT INTERRELATIONSHIPS



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.  
 FIG. 4 Zero Reference Point Related to Detecting Plane



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.  
 FIG. 5 Dummy Specimen in Specimen Holder

Type 330) or equivalent) having a thickness of 1.98 mm (0.078 in.) and an overall dimension of 1140 by 320 mm (45 by 12<sup>3</sup>/<sub>4</sub> in.) with a specimen opening of 200 by 1000 mm (7.9 by 39.4 in.). Six slots shall be cut in the flange on either side of the holder to reduce warping. The holder shall be fastened to the platform with two stud bolts at each end.

6.4 *Dummy Specimen*, used in the flux profile determination, made of 19-mm (<sup>3</sup>/<sub>4</sub>-in.) inorganic 740-kg/m<sup>3</sup> (46-lb/ft<sup>3</sup>)

nominal density calcium silicate board (Fig. 4 and Fig. 5). It is 250 mm (10 in.) wide by 1070 mm (42 in.) long with 27-mm (<sup>1</sup>/<sub>16</sub>-in.) diameter holes centered on and along the centerline at the 100, 200, 300, . . . , 900, and 980-mm locations measured from the maximum flux end of the specimen.

6.4.1 To provide proper and consistent seating of the flux meter in the hole openings, a stainless steel or galvanized steel bearing plate (Fig. 4 and Fig. 5) shall be mounted and firmly secured to the underside of the calcium silicate board with holes corresponding to those specified above. The bearing plate shall run the length of the dummy specimen board and have a width of 76 mm (3.0 in.). The thickness of the bearing plate shall be set in order to maintain the flux meter height specified in 10.5. The maximum thickness of the bearing plate shall not exceed 3 mm (<sup>1</sup>/<sub>8</sub> in.).

6.5 *Total Heat Flux Transducer*, to determine the flux profile of the chamber in conjunction with the dummy specimen (Fig. 4), shall be of the Schmidt-Boelter<sup>8</sup> type, have a range from 0 to 15 kW/m<sup>2</sup> (0 to 1.32 Btu/ft<sup>2</sup>·s) and shall be calibrated over the operating flux level range from 0.10 to 15 kW/m<sup>2</sup> in accordance with the procedure outlined in Annex A1. A source of 15 to 25°C cooling water shall be provided for this instrument.

6.5.1 *Voltmeter*, high-impedance or potentiometric, with a range from 0 to 10 mV and reading to 0.01 mV shall be used to measure the output of the total heat flux transducer during the flux profile determination.

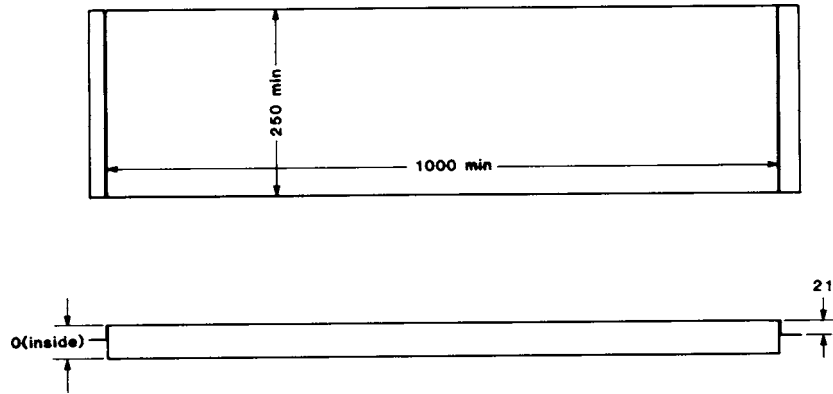
6.6 *Specimen Tray* (Fig. 6), constructed from 14-gage heat-resistant stainless steel (UNS-N08330 (AISI Type 330) or equivalent), thickness 1.98 mm (0.078 in.). The depth of the tray is 50 mm (2 in.). The flanges of the specimen tray are drilled to accommodate two stud bolts at each end; the bottom surface of the flange is 21 mm (0.83 in.) below the top edge of the specimen tray. The overall dimensions of the tray and the width of the flanges shall be such that the tray fills the open space in the sliding platform. The tray must be adequate to contain a specimen at least 1000 mm (40 in.) long and 250 mm (10 in.) wide. The zero reference point on the dummy specimen shall coincide with the pilot burner flame impingement point (Fig. 4).

6.7 *Pilot Burner*, used to ignite the specimen, is a nominal 6 mm (<sup>1</sup>/<sub>4</sub> in.) inside diameter, 10 mm (<sup>3</sup>/<sub>8</sub> in.) outside diameter stainless steel tube line burner having 19 evenly spaced 0.7 mm (0.028 in.) diameter (No. 70 drill) holes drilled radially along the centerline and 16 evenly spaced 0.7 mm (0.028 in.) diameter (No. 70 drill) holes drilled radially 60 below the centerline (Fig. 7).

6.7.1 In operation, the gas<sup>7</sup> flow is adjusted to 0.85 to 0.115 m<sup>2</sup>/h (3.0 to 4.0 SCFH) (air scale) flow rate. With the gas flow properly adjusted and the pilot burner in the test position, the pilot flame will extend from approximately 63.5 mm (2.5 in.) at the ends to approximately 127 mm (5 in.) at the center.

6.7.2 The holes in the pilot burner shall be kept clean. One means for opening the holes in the pilot burner is to use nickel-chromium or stainless steel wire that has a diameter of

<sup>8</sup> Medtherm 64-2-20, manufactured by Medtherm Corp., P.O. Box 412, Huntsville, AL 35804, has been found satisfactory for this purpose.



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.

FIG. 6 Specimen Tray

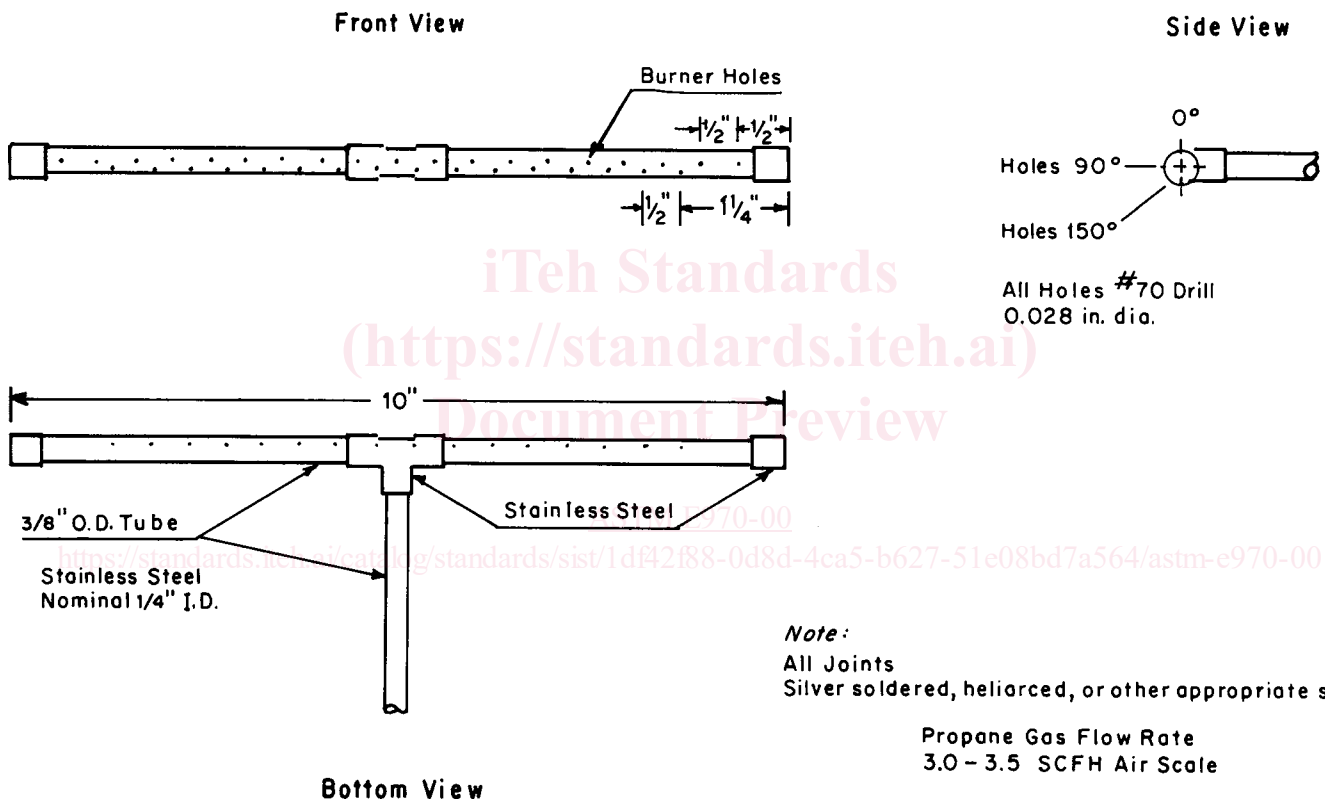


FIG. 7 Pilot Burner

0.5 mm (0.020 in.). Surface contaminants shall be removed from the burner. One means for removing contaminants is the use of a soft wire brush.

6.7.3 The pilot burner is positioned no more than 5° from the horizontal so that the flame generated will impinge on, and reach out over the specimen from the zero distance point (see Fig. 2 and Fig. 3). The burner must have the capability of being moved at least 50 mm (2 in.) away from the specimen when not in use.

6.8 *Thermocouples*—A 3.2-mm (1/8-in.) stainless steel sheathed grounded junction Chromel-Alumel thermocouple (6.8.1) shall be located in the radiant panel test chamber (Fig. 2 and Fig. 3). The chamber thermocouple is located in the

longitudinal central vertical plane of the chamber 25 mm (1 in.) down from the top and 102 mm (4 in.) back from the inside of the exhaust stack.

6.8.1 The thermocouple shall be kept clean to ensure accuracy of readout.

6.8.2 An indicating potentiometer with a range from 100 to 500°C (212 to 932°F) shall be used to determine the chamber temperature prior to a test.

6.9 *Exhaust Duct*, with a capacity of 28.3 to 85 m<sup>3</sup>/min (1000 to 3000 ft<sup>3</sup>/min) at standard temperature and pressure decoupled from the chamber stack by at least 76 mm (3 in.) on all sides and with an effective area of the canopy slightly larger than plane area of the chamber with the specimen platform in

the OUT position, is used to remove combustion products from the chamber. With the panel turned on and the dummy specimen in place, the air flow through the stack shall be  $76.2 \pm 15.2$  m/min. ( $250 \pm 50$  ft/min.) when measured with a calibrated hot-wire anemometer.<sup>9</sup> The reading is taken about 30 s after insertion of the probe into the center of the stack opening at a distance of 152 mm (6 in.) down from the top of the stack opening (Fig. 2 and Fig. 3).

6.10 A timing device with a minimum resolution of 0.10 min shall be used to measure preheat, pilot contact, time of maximum flame travel, and when all flaming goes out.

## 7. Hazards

7.1 Suitable safeguards following sound engineering practices shall be installed in the panel fuel supply to guard against a gas-air explosion in the test chamber. Consideration shall be given, but not limited to the following: (1) a gas feed cutoff activated when the air supply fails, (2) a fire sensor directed at the panel surface that stops fuel flow when the panel flame goes out, and (3) a commercial gas water heater or gas-fired furnace pilot burner control thermostatic shut-off that is activated when the gas supply fails or other suitable and approved device. Manual reset is a requirement of any safeguard system used.

7.2 In view of the potential hazard from products of combustion, the exhaust system must be so designed and operated that the laboratory environment is protected from smoke and gas. The operator shall be instructed to minimize his exposure to combustion products by following sound safety practice; for example, ensure that the exhaust system is working properly, wear appropriate clothing including gloves, etc.

## 8. Sampling

8.1 The samples selected for testing shall be representative of the product.

8.2 Standard ASTM sampling practice shall be followed where applicable; see Practice E 122 for choice of sample size to estimate the average quality of a lot or process.

## 9. Test Specimens

9.1 The test specimen shall be attic floor insulation sized to provide for adequate filling of the specimen tray (see Fig. 6).

9.2 The insulation specimen to be used for the test shall simulate actual installation practice. Typical examples are:

9.2.1 Loose-fill insulation intended for pneumatic application blown and conditioned prior to filling the specimen tray, and then gently screeded so that the insulation is level across the top of the tray.

9.2.2 Loose-fill insulation intended for pouring applications poured into the specimen tray and then gently screeded so that the insulation is level across the top of the tray.

9.2.3 Insulation batts or boards sliced to a depth of 50 mm (2 in.) and cut to fit into the specimen tray.

9.3 A minimum of three specimens per sample shall be tested.

9.4 The density of the specimen tested shall be determined by weighing the specimen tray just prior to testing. Density shall be representative of field application.

## 10. Radiant Heat Energy Flux Profile Standardization

10.1 In a continuing program of tests, the flux profile shall be determined not less than once a week. Where the time interval between tests is greater than one week, the flux profile shall be determined at the start of the test series.

10.2 Mount the dummy specimen in the mounting frame, and attach the assembly to the sliding platform.

10.3 With the sliding platform out of the chamber, turn on the exhaust, and ignite the radiant panel. Allow the unit to heat for 1.5 h. The pilot burner is off during this determination. Adjust the fuel mixture to give an air-rich flame. Make fuel flow settings to bring the panel blackbody temperature to  $485 \pm 25^\circ\text{C}$  ( $839 \pm 45^\circ\text{F}$ ) and record the chamber temperature. After the panel blackbody temperature has stabilized, move the specimen platform into the chamber and close the door.

10.4 Allow 0.5 h for the closed chamber to equilibrate.

10.5 Measure the radiant heat energy flux level at the 400-mm point with the total flux meter instrumentation. This is done by inserting the flux meter in the opening so that its detecting plane is 1.6 to 3.2 mm ( $1/16$  to  $1/8$  in.) above and parallel to the plane of the dummy specimen and reading its output after  $30 \pm 10$  s. If the level is within the limits specified in 10.6, start the flux profile determination. If it is not, adjust the panel fuel flow as required to bring the level within the limits specified in 10.6. A suggested flux profile data log format is shown in Fig. 8.

10.6 Run the test under chamber operating conditions that give a flux profile as shown in Fig. 9. The radiant heat energy incident on the dummy specimen shall be between 8.7 and 9.5  $\text{kW/m}^2$  (0.77 and 0.83  $\text{Btu/ft}^2\cdot\text{s}$ ) at the 200-mm point, between 4.8 and 5.2  $\text{kW/m}^2$  (0.42 and 0.46  $\text{Btu/ft}^2\cdot\text{s}$ ) at the 400-mm point, and between 2.2 and 2.6  $\text{kW/m}^2$  (0.19 and 0.23  $\text{Btu/ft}^2\cdot\text{s}$ ) at the 600-mm point.

10.7 Insert the flux meter in the 100-mm opening following the procedure given in 10.5. Read the millivolt output at  $30 \pm 10$  s and proceed to the 200-mm point. Repeat the 100-mm procedure. Determine the 300 to 980-mm flux levels in the same manner. Following the 980-mm measurement, make a check reading at 400-mm. If this is within the limits set forth in 10.6, the test chamber is in calibration, and the profile determination is completed. If not, adjust fuel flow, allow 0.5 h for equilibrium, and repeat the procedure.

10.8 Plot the radiant heat energy flux data as a function of distance along the specimen plane on rectangular coordinate graph paper. Draw a smooth curve through the data points. This curve will hereafter be referred to as the flux profile curve.

10.9 Determine the open chamber temperature and radiant panel blackbody temperature identified with the standard flux profile by opening the door and moving the specimen platform out. Allow 0.5 h for the chamber to equilibrate. Read and record, in degrees Celsius, the chamber temperature and the optical pyrometer output that gives the panel blackbody temperature. These temperature settings shall be used in subsequent test work instead of measuring the dummy specimen radiant flux at 200, 400, and 600 mm.

<sup>9</sup> Omega HH-615 HT manufactured by Omega Engineering, Inc., Box 4047, Stamford, CT 06907, has been found satisfactory.