Designation: ~~E648 – 19a$^{\varepsilon 1}$~~ E648 – 23

An American National Standard

Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source[1]

This standard is issued under the fixed designation E648; 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 (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

~~ε1 NOTE—In A2.2.1(1) (b), the value for density was corrected editorially from 1333 kg/m^3 to 1442 kg/m^3 in January 2020.~~

1. Scope*

1.1 This fire-test-response standard covers a procedure for measuring the critical radiant flux of horizontally mounted floor-covering systems exposed to a flaming ignition source in a graded radiant heat energy environment in a test chamber. A specimen is mounted over underlayment, a simulated concrete structural floor, bonded to a simulated structural floor, or otherwise mounted in a typical and representative way.

1.2 This fire-test-response standard measures the critical radiant flux at flame-out. It provides a basis for estimating one aspect of fire exposure behavior for floor-covering systems. The imposed radiant flux simulates the thermal radiation levels likely to impinge on the floors of a building whose upper surfaces are heated by flames or hot gases, or both, from a fully developed fire in an adjacent room or compartment. The standard was developed to simulate an important fire exposure component of fires that develop in corridors or exitways of buildings and is not intended for routine use in estimating flame spread behavior of floor covering in building areas other than corridors or exitways. See Appendix X1 for information on proper application and interpretation of experimental results from use of this test.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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 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 appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements are given in Section 7.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] 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 ~~Dec. 1, 2019~~Nov. 1, 2023. Published ~~December 2019~~December 2023. Originally approved in 1978. Last previous edition approved in 2019 as E648~~–19.~~ –19a$^{\varepsilon 1}$. DOI: ~~10.1520/E0648-19AE01.~~ 10.1520/E0648-23.

***A Summary of Changes section appears at the end of this standard**

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1186 Specification for Flat Fiber-Cement Sheets
C1288 Specification for Fiber-Cement Interior Substrate Sheets
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E136 Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750 °C
~~E171~~E171/E171M Practice for Conditioning and Testing Flexible Barrier Packaging
E176 Terminology of Fire Standards

3. Terminology

3.1 *Definitions*—See Terminology E176 for additional definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *blackbody temperature, n*—the temperature of a perfect radiator—a surface with an emissivity of unity and, therefore, a reflectivity of zero.

3.2.2 *corridor, n*—an enclosed space connecting a room or compartment with an exit. The corridor includes normal extensions, such as lobbies and other enlarged spaces, where present.

3.2.3 *critical radiant flux, n*—the level of incident radiant heat energy on the floor covering system at the most distant flame-out point. It is reported as W/cm^2 .

3.2.4 *flame-out, n*—the time at which the last vestige of flame or glow disappears from the surface of the test specimen, frequently accompanied by a final puff of smoke.

3.2.5 *floor covering, n*—an essentially planar material having a relatively small thickness in comparison to its length or width, which is laid on a floor to enhance the beauty, comfort, and utility of the floor.

3.2.6 *floor covering system, n*—a single material, composite or assembly comprised of the floor covering and related installation components (adhesive, cushion, etc.), if any.

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

3.2.8 *time zero, n*—the point in time when the chamber door is closed, which needs to occur within 3 s after the specimen has been moved into the chamber (see 12.4).

3.2.9 *total flux meter, 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 The basic elements of the test chamber are (*1*) an air-gas fueled radiant heat energy panel inclined at 30° to and directed at (*2*) a horizontally mounted floor covering system specimen, Fig. 1. The radiant panel generates a radiant energy flux distribution ranging along the ~~100-cm~~100 cm length of the test specimen from a nominal maximum of 1.0 W/cm^2 to a minimum of 0.1 W/cm^2. The test is initiated by open-flame ignition from a pilot burner. The distance burned to flame-out is converted to watts per square centimeter from the flux profile graph, Fig. 2, and reported as critical radiant flux, W/cm^2.

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 of a

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

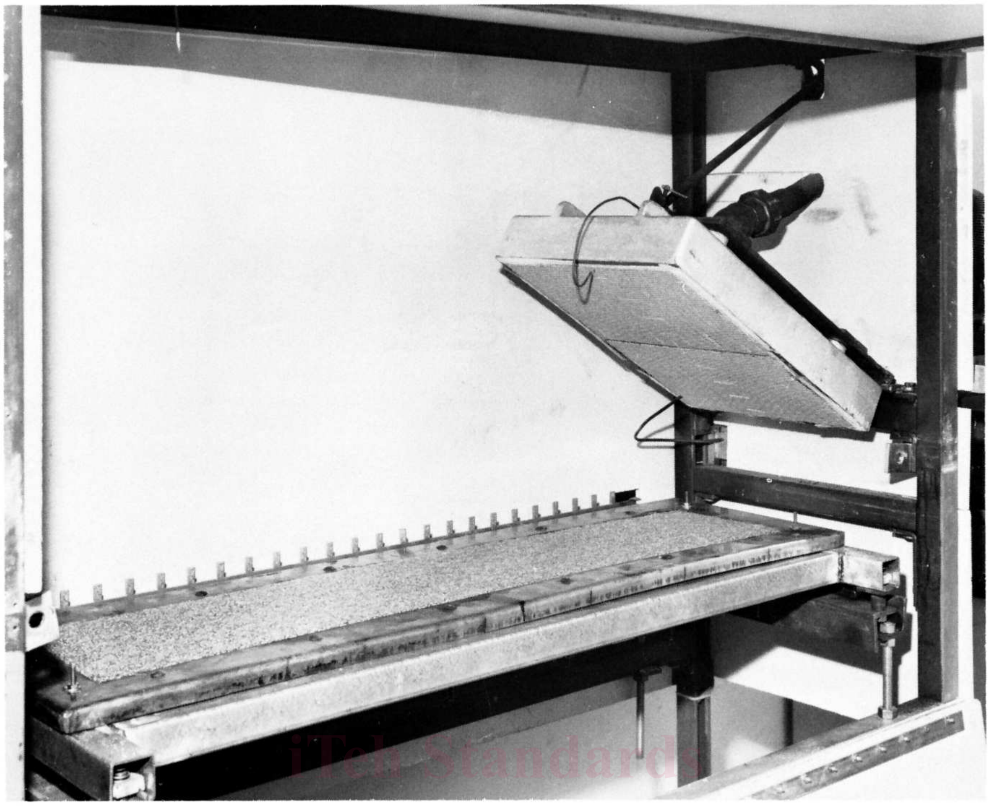


FIG. 1 Flooring Radiant Panel Test Showing Carpet Specimen and Gas Fueled Panel

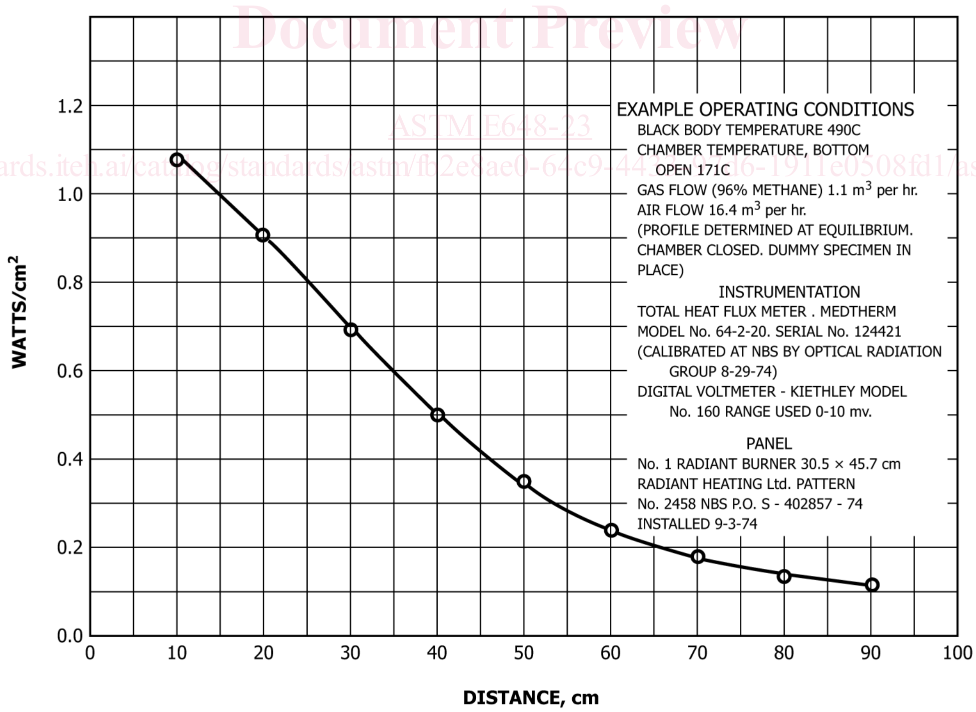


FIG. 2 Standard Radiant Heat Energy Flux Profile

floor-covering system installed in a building corridor. The test environment is intended to simulate conditions that have been observed and defined in full scale corridor 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 sensitivity to flame spread of floor-covering systems in a building corridor.

5.4 The test is applicable to floor-covering system specimens that follow or simulate accepted installation practice. Tests on the individual elements of a floor system are of limited value and not valid for evaluation of the flooring system.

5.5 In this procedure, the specimens are subjected to one or more specific sets of laboratory test conditions. If different test conditions are substituted or the end-use conditions are changed, it is not always possible by or from this test method to predict changes in the fire-test-response characteristics measured. Therefore, the results are valid only for the fire test exposure conditions described in this procedure.

6. Apparatus

6.1 *General:*

6.1.1 The test chamber employed for this test shall be located in a draft-protected laboratory.

6.2 *Test Chamber:*

6.2.1 The test chamber, Fig. 3 and Fig. 4, shall consist of an enclosure ~~1400~~1400 mm ± 10 mm long by ~~500~~500 mm ± 10 mm deep by ~~710~~710 mm ± 10 mm above the test specimen. The sides, ends, and top shall be of ~~13-mm~~13 mm calcium silicate, 0.74 g/cm^3 nominal density, insulating material with a thermal conductivity at ~~177°C~~177 °C of 0.128 W/(m·K). One side shall be provided with an approximately ~~100 by 1100-mm~~100 mm by 1100 mm draft-tight fire-resistant glass window so the entire length of the test specimen is observable from outside the chamber.

6.2.2 The bottom of the test chamber shall consist of a sliding steel platform that has provisions for rigidly securing the test specimen holder in a fixed and level position. The free, or air access, area around the platform shall be ~~2300~~2300 cm^2 to 3225 cm^2.

6.2.3 When the rate of 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.

6.2.4 When the extent of flame travel is to be measured after a prescribed burning period, for example, 15 min, the metal scale described in 6.2.3 shall be used.

6.2.5 The top of the chamber shall have an exhaust stack with interior dimensions of ~~102~~102 mm ± 3 mm wide by ~~380~~380 mm ± 3 mm deep by ~~318~~318 mm ± 3 mm high at the opposite end of the chamber from the radiant panel.

6.3 *Radiant Heat Energy Source:*

6.3.1 The radiant heat energy source shall be a panel of porous material mounted in a cast iron or steel frame with a radiation surface of ~~305~~305 mm by 457 mm. It shall be capable of operating at temperatures up to ~~816°C.~~816 °C. The panel fuel system shall consist of a venturi-type aspirator for mixing gas[3] and air at approximately atmospheric pressure, a clean, dry air supply capable of providing 28.3 NTP m^3/h at 76 mm of water, and suitable instrumentation for monitoring and controlling the flow of fuel to the panel.

6.3.2 The radiant heat energy panel shall be mounted in the chamber at an angle of ~~30~~30° ± 5° to the horizontal specimen plane. The horizontal distance from the 0 mark on the specimen fixture to the bottom edge (projected) of the radiating surface of the panel shall be ~~89~~89 mm ± 3 mm. The panel-to-specimen vertical distance shall be ~~140~~140 mm ± 3 mm (See Fig. 3).

[3] Gas used in this test shall be commercial grade propane having a heating value of approximately 83.1 MJ/m^3 , commercial grade methane having a minimum purity of 96 %, or natural gas.

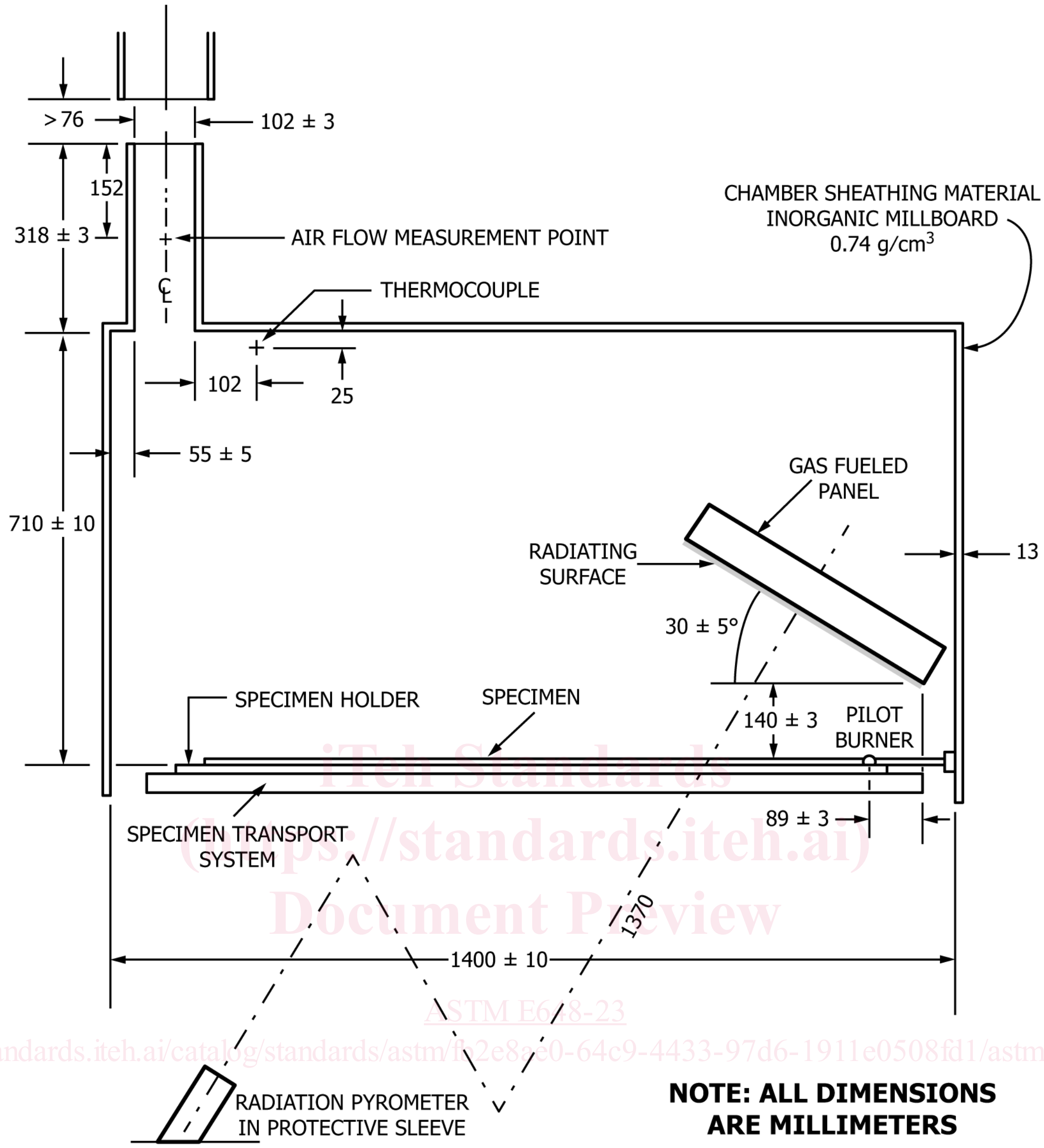


FIG. 3 Flooring Radiant Panel Tester Schematic Side Elevation

6.4 *Pyrometer:*

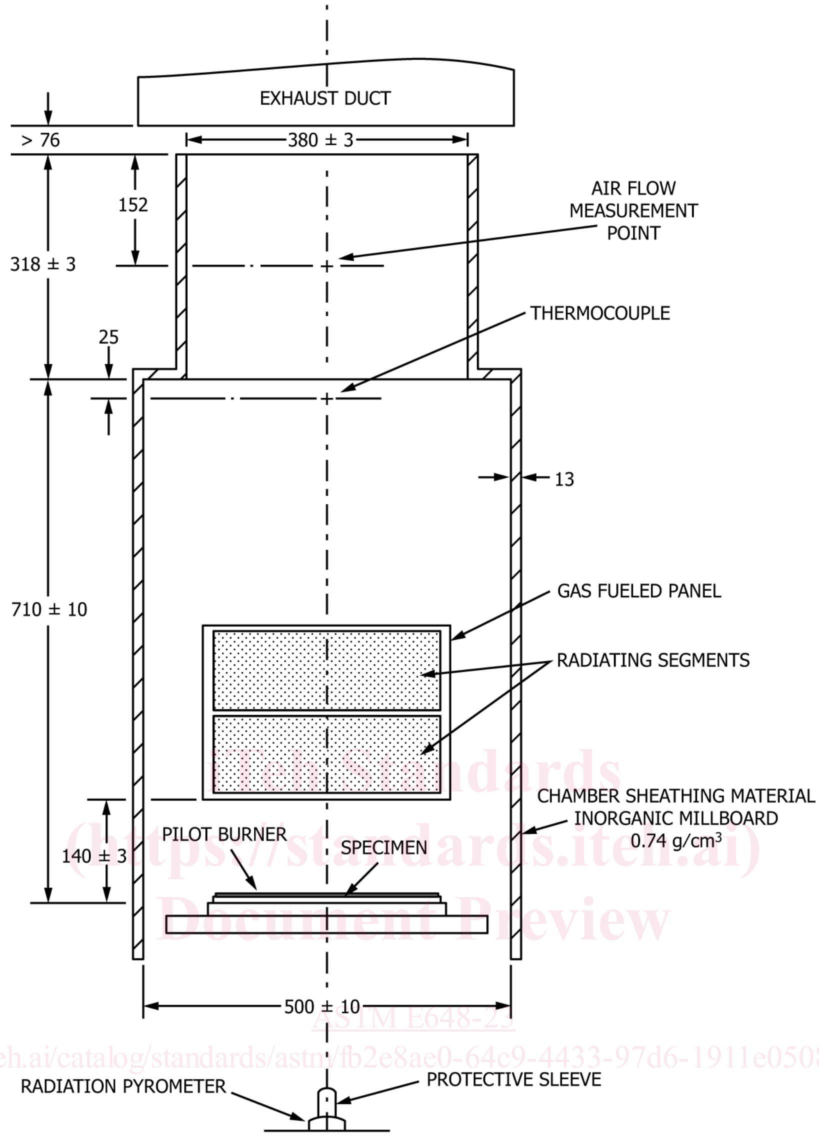
6.4.1 The radiation pyrometer for standardizing the thermal output of the panel shall be suitable for viewing a circular area ~~178-254~~ 178 mm to 254 mm in diameter at a range of 1.37 m. It shall be calibrated over the ~~490 to 510°C~~490 °C to 510 °C operating blackbody temperature range in accordance with the procedure described in Annex A1.

6.5 *Specimen Holder:*

6.5.1 The specimen holder (see Fig. 5) shall be constructed from heat-resistant stainless steel having a thickness of ~~1.98 mm~~ 1.98 mm and an overall dimension of ~~1140~~1140 mm by 320 mm with a specimen opening of ~~200~~200 mm ± 3 mm by ~~1000 + 15 mm -0 mm.~~ 1000 mm + 15 mm -0 mm. 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.

6.6 *Pilot Burner:*

6.6.1 The pilot burner, used to ignite the specimen, shall be a nominal 6 mm inside diameter, 10 mm outside diameter stainless



NOTE: ALL DIMENSIONS ARE MILLIMETERS

FIG. 4 Flooring Radiant Panel Tester Schematic Low Flux End, Elevation

steel tube line burner having 19 evenly spaced 0.7 mm diameter (#70 drill) holes drilled radially along the centerline, and 16 evenly spaced 0.7 mm diameter (#70 drill) holes drilled radially 60° below the centerline (see Fig. 6).

6.6.2 In operation, the gas flow shall be adjusted to ~~0.085~~0.085 m^3/h to 0.100 m^3/h ~~(3.0~~(3.0 SCFH to 3.5 SCFH) (air scale) flow rate. The pilot burner shall be positioned no more than 5° from the horizontal so the flame generated will impinge on the specimen at the 0 distance burned point (see Fig. 3 and Fig. 4).

6.6.3 When the burner is not being applied to the specimen, it shall be capable of being moved at least 50 mm away from the specimen.

6.6.4 With the gas flow properly adjusted and the pilot burner in the test position, the pilot flame shall extend from approximately 63.5 mm at either end to approximately 127 mm at the center.

6.6.5 The holes in the pilot burner shall be kept clean. A soft wire brush has been found suitable to remove the surface contaminants. Nickel-chromium or stainless steel wire with an outside diameter of 0.5 mm is suitable for opening the holes.

6.7 *Thermocouples:*

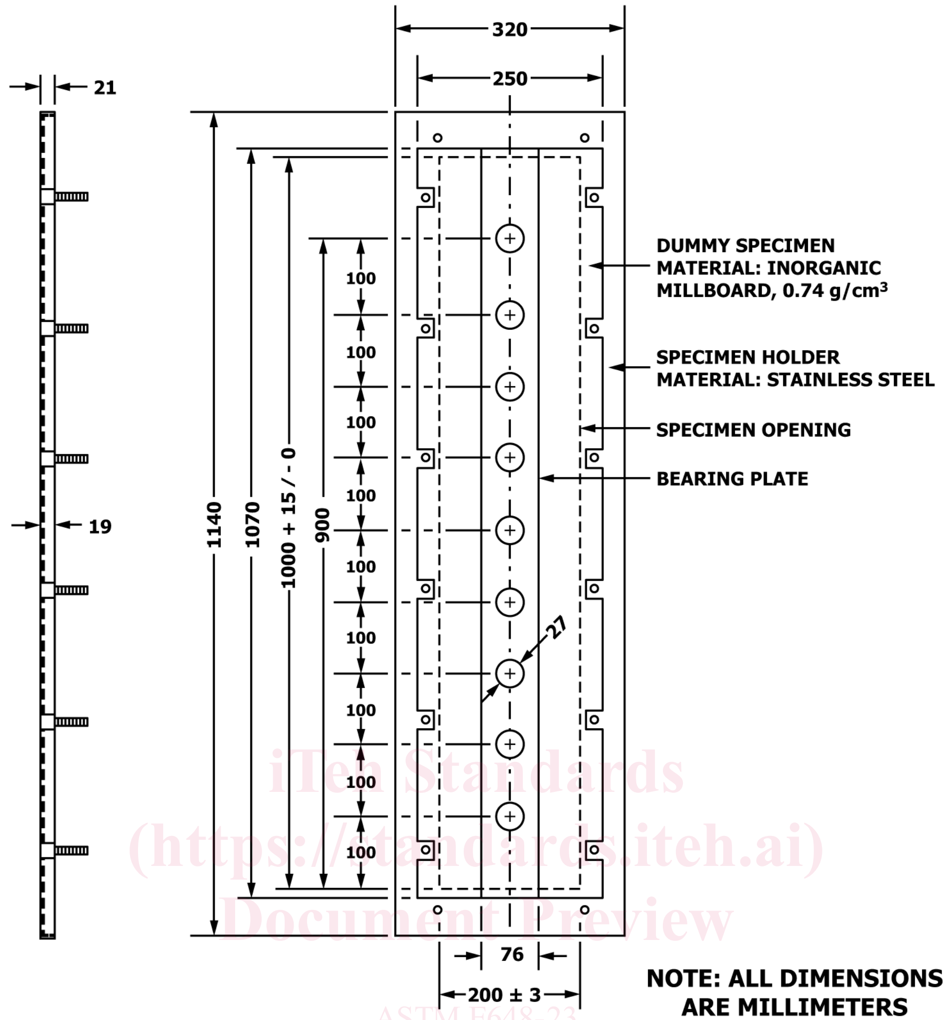


FIG. 5 Dummy Specimen in Specimen Holder (Bottom View)

6.7.1 A ~~3.2-mm~~3.2 mm stainless steel sheathed grounded junction Chromel-Alumel thermocouple shall be located in the flooring radiant panel test chamber (see Fig. 3 and Fig. 4). The chamber thermocouple is located in the longitudinal central vertical plane of the chamber 25 mm down from the top and 102 mm back from inside the exhaust stack.

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

6.8 *Exhaust System:*

6.8.1 An exhaust duct with a capacity of ~~28.3~~ 28.3 NTP m^3/min to 85 NTP m^3/min decoupled from the chamber stack by at least 76 mm 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.

6.8.1.1 Before igniting the panel, but with the exhaust hood operating and the dummy specimen in place, the air flow rate through the stack shall be ~~76.2~~76.2 m/min ± 15.2 m/min when measured with a hot wire anemometer at least 30 s after insertion of the probe into the center of the stack opening at a distance of 152 mm down from the top of the stack opening.

6.8.1.2 The hot wire anemometer shall have an accuracy of ±0.1 m/s.

6.9 *Dummy Specimen:*

6.9.1 The dummy specimen that is used in the flux profile determination shall be made of ~~19-mm~~19 mm inorganic 0.74 g/cm^3

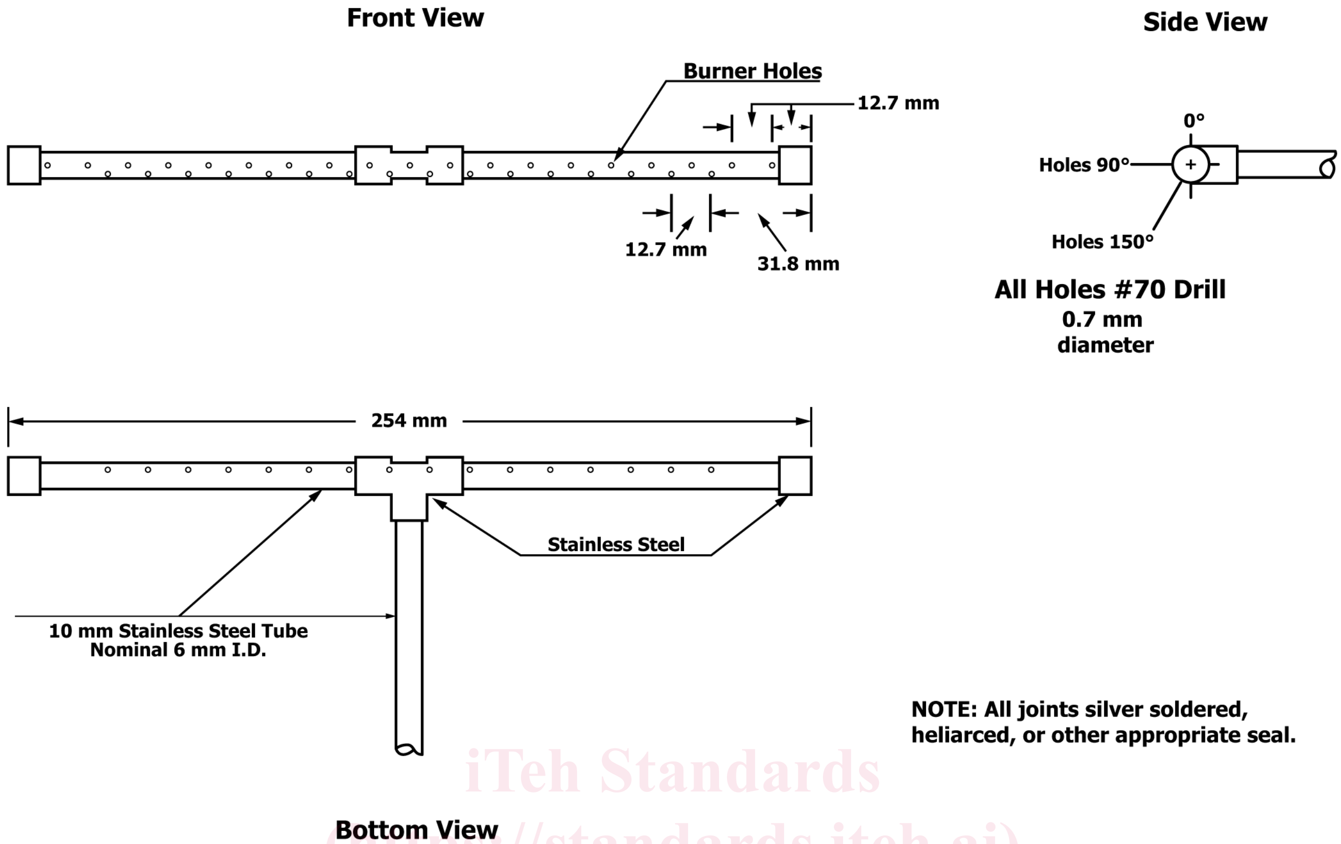


FIG. 6 Pilot Burner

nominal density calcium silicate board (see Fig. 5). It shall be 250 mm wide by 1070 mm long with ~~27-mm~~27 mm diameter holes centered on and along the centerline at the ~~100, 200, 300,~~100 mm, 200 mm, 300 mm, ... , 900 mm locations, measured from the maximum flux end of the specimen. To provide proper and consistent seating of the flux meter in the hole openings, a stainless or galvanized steel bearing plate shall be mounted and firmly secured to the underside of the calcium silicate board with holes corresponding to those previously specified. The bearing plate shall run the length of the dummy specimen and have a width of 76 mm. The thickness of the bearing plate shall be varied as necessary to maintain the flux meter height specified in 10.5 up to 3.2 mm maximum.

6.10 *Heat Flux Transducer:*

6.10.1 The total heat flux transducer used to determine the flux profile of the chamber in conjunction with the dummy specimen shall be of the Schmidt-Boelter[4] type, have a range from ~~0~~0 W/cm^2 to 1.5 W/cm^2, and shall be calibrated over the operating flux level range from ~~0.10~~0.10 W/cm^2 to 1.5 W/cm^2 in accordance with the procedure outlined in Annex A1. A source of ~~15 to 25°C~~15 °C to 25 °C cooling water shall be provided for this instrument.

6.10.2 The heat flux transducer output shall be measured with a data acquisition system or a high impedance or potentiometric voltmeter with a range from ~~0~~0 mV to 10 mV and reading to 0.01 mV.

6.11 *Timing Device:*

6.11.1 A timing device with a minimum resolution of ~~0.10 min~~ 0.10 min shall be used to measure preheat, pilot contact, and flame-out times.

[4] The sole source of supply of the apparatus known to the committee at this time is Medtherm Corp., P.O. Box 412, Huntsville, AL 35804. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

7. Hazards

7.1 Suitable safeguards following sound engineering practices shall be installed in the panel fuel supply to guard against a gas-air fuel explosion in the test chamber. Consideration shall be given, but not limited to the following: (*1*) a gas feed cut-off 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, (*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 the 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 E122 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 the floor-covering system sized to provide for adequate clamping in the mounting frame. Its minimum dimensions shall exceed the frame width ~~(200 mm~~ (200 mm nominal) and length ~~(1000 mm~~ (1000 mm nominal) by approximately ~~50 mm.~~50 mm.

9.1.1 Holes shall be made in the specimen to accommodate the bolts when required to secure the specimen to the mounting frame (see Fig. 5).

~~9.1.2 For tiles, samples shall be representative of the largest dimension tile manufactured. The specimen shall be mounted so that the first joint is located the farthest possible distance from the zero point. As an alternative, select samples from roll or sheet goods prior to cutting into tiles. The test results are applicable to identical tiles of smaller dimensions.~~

~~9.1.2.1 If the tile is not sufficiently wide to cover the width of the specimen holder, the tile shall be mounted to include a longitudinal joint at the center line of the specimen holder.~~

~~9.1.2.2 If the tiles are not glued, the edges shall be mechanically secured to the substrate.~~

9.2 The floor-covering system is to be specified by the test sponsor. In the absence of a specified floor-covering system, select one of the following:

9.2.1 A carpet mounted over the cushion proposed for use, or over the cushion recommended by the carpet manufacturer for use in the installation, tested over the standard simulated concrete subfloor (see A2.2.1).

9.2.2 A carpet with or without integral cushion pad bonded to the standard simulated concrete subfloor (see A2.2.2).

9.2.3 A resilient floor bonded to the standard simulated concrete subfloor (see A2.3.1).

9.2.4 A hardwood floor nailed to a plywood subfloor, sanded, and finished in accordance with standard practice (see A2.4.1).

9.2.5 A laminate floor mounted over the proposed cushion or simulated concrete subfloor (see A2.5).

9.3 For tiles, samples shall be representative of the largest dimension tile manufactured. The specimen shall be mounted so that the first joint is located the farthest possible distance from the zero point. As an alternative, select samples from roll or sheet goods prior to cutting into tiles. The test results are applicable to identical tiles of smaller dimensions.

9.3.1 If the tiles are not glued, the edges shall be mechanically secured to the substrate.

9.4 A flooring material intended for installation in the form of planks, tiles, cove, or base ~~having an overall width greater than the opening in the specimen holder, 200 mm~~ shall include at least one longitudinal joint located at the approximate centerline of the specimen holder. For materials having a production width less than the opening of the specimen holder, 200 mm, ~~the~~ one longitudinal joint shall be located at the approximate centerline of the specimen holder and all other joints shall be located as necessary to complete the specimen assembly.

9.5 Three specimens per sample shall be tested.

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, 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 approximately ~~500°C~~500 °C and record the chamber temperature. When equilibrium has been established, 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~~400 mm point with the total flux meter instrumentation. This is done by inserting the flux meter in the opening so its detecting plane is ~~1.6~~1.6 mm to 3.2 mm above and parallel to the plane of the dummy specimen and reading its output after ~~30~~30 s ± 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. 7.

10.6 Run the test under chamber operating conditions that give a flux profile as shown in Fig. 2. The radiant heat energy incident on the dummy specimen shall be between ~~0.87~~0.87 W/cm^2 and 0.95 W/cm^2 at the ~~200-mm~~200 mm point, between ~~0.48~~0.48 W/cm^2 and 0.52 W/cm^2 at the ~~400-mm~~400 mm point, and between ~~0.22~~0.22 W/cm^2 and 0.26 W/cm^2 at the ~~600-mm~~600 mm point.

10.7 Insert the flux meter in the ~~100-mm~~100 mm opening following the procedure given in 10.5. Read the output at ~~30~~30 s ± 10 s and proceed to the ~~200-mm~~200 mm point. Repeat the ~~100-mm~~100 mm procedure. Determine the ~~300 to 900-mm~~300 mm to 900 mm flux levels in the same manner. Following the ~~900-mm~~900 mm measurement, make a check reading at ~~400-mm.~~400 mm.

Radiant Flux Profile

Date ________
Blackbody Temperature ______mV. ______ °C
Gas Flow ______ NTP m^3/h (SCFH) Air Flow ______ NTP m^3/h (SCFH)
Room Temperature ______ °C
Air Pressure ______ Gas ______ mm of H_2O
Flux Meter Conversion Factor ______
Radiometer No. ______ from Calibration on ______

Distance, mm	mV	W/cm^2
100	______	______
200	______	______
300	______	______
400	______	______
500	______	______
600	______	______
700	______	______
800	______	______
900	______	______

Signed ____________________

FIG. 7 Flux Profile Data Log Format