



Designation: D3675 – 17

# Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source<sup>1</sup>

This standard is issued under the fixed designation D3675; 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 is a fire test response standard.

1.2 This test method describes the measurement of surface flammability of flexible cellular materials.

1.3 *This standard measures and describes 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.*

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

1.5 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

1.6 Specific information about hazards is given in Section 7.  
NOTE 1—There is no known ISO equivalent to this standard.

1.7 The values stated in SI units are to be regarded as the standard. The values stated in inch-pound units, in parentheses, are for information only and are approximations (see also IEEE/ASTM SI-10).

1.8 *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.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties.

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<sup>2</sup> 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.

E84 Test Method for Surface Burning Characteristics of Building Materials

E162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

E176 Terminology of Fire Standards

E1317 Test Method for Flammability of Marine Surface Finishes

E1321 Test Method for Determining Material Ignition and Flame Spread Properties

E1546 Guide for Development of Fire-Hazard-Assessment Standards

IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *ISO Standards:*<sup>3</sup>

ISO 13943 Fire Safety—Vocabulary

## 3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to the terminology contained in Terminology E176 and ISO 13943. In case of conflict, the definitions given in Terminology E176 shall prevail.

3.1.2 *flame front, n*—the leading edge of a flame propagating through a gaseous mixture or across the surface of a liquid or solid.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flashing, n*—flame fronts of three seconds or less in duration.

3.2.2 *radiant panel index, I<sub>r</sub>, n*—the product of the flame spread factor,  $F_s$ , and the heat evolution factor,  $Q$ .

## 4. Summary of Test Method

4.1 This test method of measuring surface flammability of flexible cellular materials employs a radiant panel heat source consisting of a 300 by 460-mm (12 by 18-in.) panel in front of which an inclined 150 by 460-mm (6 by 18-in.) specimen of the material is placed. The orientation of the specimen is such that ignition is forced near its upper edge and the flame front progresses downward.

<sup>3</sup> Available from International Standardization Organization, P.O. Box 56, CH-1211; Geneva 20, Switzerland.

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

4.2 Factors derived from the rate of progress of the flame front and the rate of heat liberated by the material under test are combined to provide a radiant panel index.

## 5. Significance and Use

5.1 This test method is intended for use when measuring surface flammability of flexible cellular materials exposed to fire. The test method provides a laboratory test procedure for measuring and comparing the surface flammability of materials when exposed to a prescribed level of radiant heat energy. The test is conducted using specimens that are representative, to the extent possible, of the material or assembly being evaluated. For example, if an assembly is required to be tested, such specimens shall replicate the type and thickness of all the layers present in the assembly being evaluated.

5.2 The rate at which flames will travel along surfaces depends upon the physical and thermal properties of the material, product, or assembly under test, the specimen mounting method and orientation, the type and level of fire or heat exposure, the availability of air, and properties of the surrounding enclosure. (1-6)<sup>4, 5</sup>

5.3 Test Method E162 is a generic version of this test method, using an apparatus that is substantially the same as the one used in this test method. However, Test Method E162 is normally intended for application to specimens other than flexible cellular materials.

5.3.1 The pilot burner in this test method is different from the pilot burner in Test Method E162.

5.4 In this procedure, the specimens are subjected to one or more specific sets of laboratory fire 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 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.

5.5 If the test results obtained by this test method are to be considered as part of an overall assessment of fire hazard in a building or structure, then the criteria, concepts and procedures incorporated into Guide E1546 shall be taken into consideration.

## 6. Apparatus

6.1 The apparatus shall be essentially as shown in Fig. 1 and shall include the following:

6.1.1 *Radiant Panel with Air and Gas Supply*—The radiant panel shall consist of a porous refractory material vertically mounted in a cast iron frame, exposing a radiating surface of 300 by 460 mm (12 by 18 in.) and shall be capable of operating at temperatures up to 820°C (1500°F). The panel shall be equipped (see Fig. 1) with a venturi-type aspirator for mixing gas and air at approximately atmospheric pressure; a centrifugal blower, or equivalent, capable of providing 9.4 dm<sup>3</sup>/s (1200 ft<sup>3</sup>/hour) air at a pressure of 0.7 kPa (2.8 in. water); an air filter

to prevent dust from obstructing the panel pores; a pressure regulator and a control and shut-off valve for the gas supply.

6.1.2 *Specimen Holder*—The specimen holder shall conform in shape and dimension to Fig. 2 and be constructed from heat-resistant chromium steel, or other suitable non-combustible material which will not be affected by the heat input during the test. Observation marks shall be filed on the surface of the specimen holder to correspond with 75-mm (3-in.) interval lines on the specimen.

6.1.2.1 The calibration process (see A1.2) shall be conducted with the specimen holder to be used in the tests to ensure that the physical characteristics of the construction material do not affect the test results.

6.1.3 *Framework for Support of the Specimen Holder*—The framework shall have two transverse rods of stainless steel, each 12.5 mm ± 3.0 mm (0.5 ± 0.13 in.) in diameter, with a stop to center the specimen holder directly in front of the radiant panel. The support and bracing members shall be constructed from metal stock. Since the angle of the specimen and its position with respect to the panel are critical, the framework dimensions specifying these conditions shall be within 3.0 mm (0.13 in.) of the values given in Fig. 1.

6.1.4 *Pilot Burner*—The pilot burner shall be a porcelain tube 203-230 mm (8-9 in.) in length, nominally 6.3 mm (0.25 in.) in diameter, with two holes 1.5 ± 0.1 mm (0.059 ± 0.004 in.) in diameter equally spaced in the tube (see Fig. 3). The burner shall be mounted horizontally and at an angle of 15 to 20° to the intersection of the horizontal plane of the burner with the plane of the specimen with the outlet end of the burner spaced 32 ± 2 mm (1.25 ± 0.1 in.) from the specimen (see Fig. 3). The pilot shall provide a 150 to 180-mm (6 to 7-in.) flame of acetylene gas premixed with air in an aspirating type fitting. Properly adjusted, the pilot flame shall have 25-mm (1-in.) inner blue cones and should impinge on the upper central surface of the specimen within 13 mm (0.5 in.) of the edge of the specimen support frame. Flow rates of 0.015 dm<sup>3</sup>/s (0.032 ft<sup>3</sup>/min) of acetylene and 0.075 dm<sup>3</sup>/s (0.16 ft<sup>3</sup>/min) of air have been found to provide the desired flame.

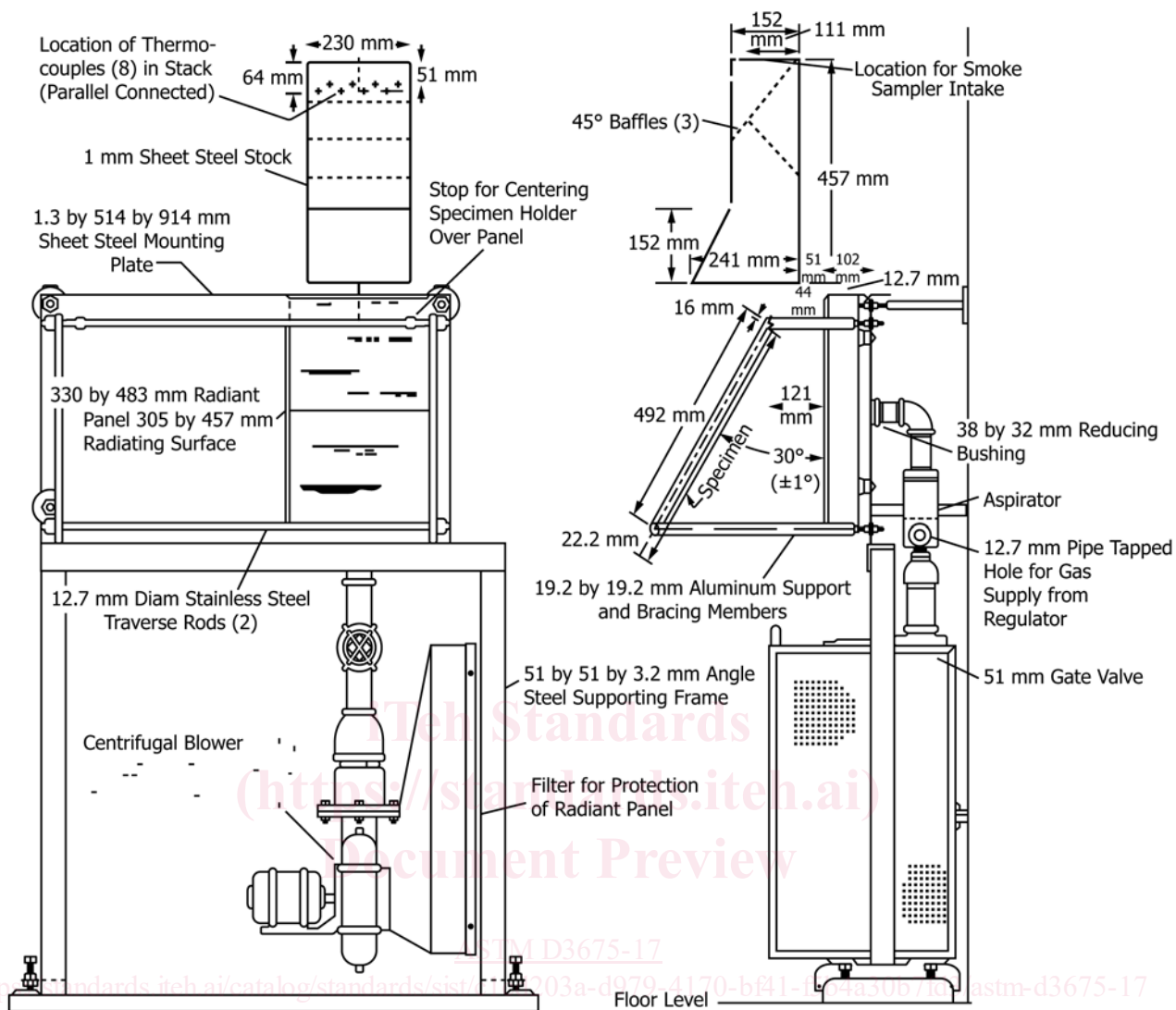
6.1.5 *Stack*—The stack shall be made from nominally 1.0-mm (0.040-in.) sheet steel with shape and dimensions as shown in Fig. 1. The position of the stack with respect to the specimen and radiant heat panel shall also comply with the requirements of Fig. 1.

6.1.6 *Thermocouples*—Eight thermocouples of equal resistance and connected in parallel shall be mounted in the stack and supported with porcelain insulators as indicated in Fig. 1 and Fig. 4. The thermocouples shall be Chromel-Alumel Type K, shielded against high heat with insulation resisting up to 1200°C (2190°F), and with wire gages in the range of 0.36-0.51 mm (0.14-0.20 in.) (30 AWG-24 AWG) diameter. The mean stack thermocouple temperature rise for unit heat input rate of the calibration burner, β, shall be determined periodically for the specific test apparatus, using the procedure in A1.2.

6.1.7 *Automatic Potentiometer Recorder*—An automatic potentiometer recorder in the range from 38 to 538°C (100 to 1000°F) shall be installed to record the temperature variation of the stack thermocouples as described in 6.1.6. Alternatively,

<sup>4</sup> The boldface numbers in parentheses refer to a list of references at the end of this standard.

<sup>5</sup> Also see Test Method E162.



Metric Equivalents

mm	in.	mm	in.
1.0	0.040	152	6
12.7	1/2	241	9 1/2
16.0	5/8	457	18
22.2	7/8	492	19 3/8
44	1 3/4	19.1 by 19.1	3/4 by 3/4
51	2	38 by 32	1 1/2 by 1 1/4
64	2 1/2	305 by 457	12 by 18
71	2.8	330 by 483	13 by 19
102	4	51 by 51 by 3.2	2 by 2 by 1/8
111	4 3/8	1.3 by 514 by 914	0.050 by 20 1/4 by 36
121	4 3/4		

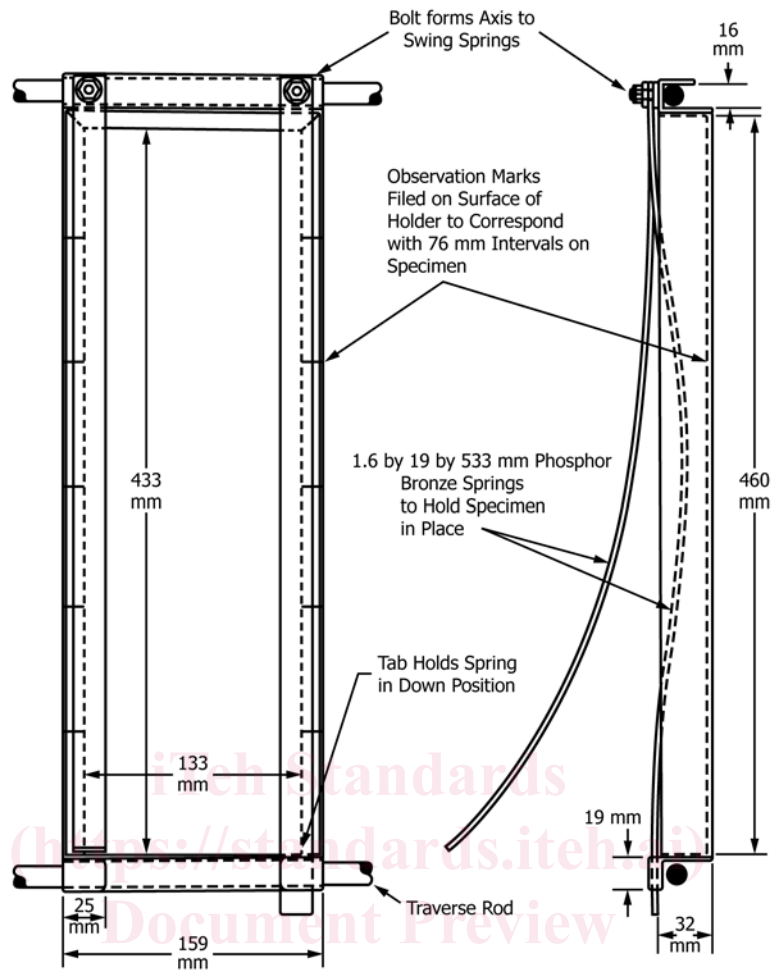
100 cfm 47.21 litres/s

FIG. 1 Details of Construction of Test Equipment

a computerized data acquisition system shall be permitted to be used. The data acquisition system shall have facilities to record the temperature output from the thermopile. The data acquisition system shall have an accuracy of 0.01 % of the maximum temperature to be measured. Whichever system is used, it shall be capable of recording, or printing, data at least every 5 s for

a minimum of 1 h. For cases where preliminary tests indicate rapid flame spread, a system shall be used capable of acquiring data fast enough to ensure adequate results (see 11.6).

6.1.8 Hood—A hood with exhaust blower placed over the stack is required. Before igniting the panel, but with the exhaust hood operating, the air flow rate through the stack shall



ASTM D3675 - 17  
Metric Equivalents

mm	in.	mm	in.
19.0	¾	159	6 ¼
25	1	433	17 ⅝
32	1 ¼	460	18 ⅞
76	3	1.6 by 19 by 533	⅛ by ¾ by 21
133	5 ¼		

FIG. 2 Specimen Holder

produce a nominal velocity of 0.5 m/s (100 ft/min, 30 m/min). Measurements are to be made either with a hot wire anemometer after at least 30 seconds of insertion of the probe into the center of the stack at a distance of 152 mm (6 in.) down from the top of the stack opening, or with a bi-directional probe or similar device at the top of the stack opening. The hot wire anemometer, bi-directional probe or similar device, shall have an accuracy of  $\pm 0.1$  m/s (19 ft/min).

6.1.8.1 In order to facilitate the insertion of the hot wire anemometer probe, a hole of adequate diameter to allow its insertion shall be pre-drilled through the hood, in the center of either of the 152 mm (6 in.) wide surfaces, so as to prevent contact of the probe with the internal baffles. The hole is intended to be used for insertion of the probe and shall be plugged after the air flow rate has been established and before testing.

6.1.8.2 The velocity is not critical for flame spread measurements provided a stack thermocouple calibration is performed (see 6.1.6 and A1.2) for the established test conditions. The hood surfaces shall clear the top and sides of the stack by a minimum of 250 mm (10 in.) and 190 mm (7.5 in.), respectively.

6.1.8.3 Testing has shown that the air flow rate through the stack, if measured during operating conditions using a bi-directional probe or similar device, produces a velocity of approximately 1.3 m/s (250 ft/min).

6.1.9 *Radiation Pyrometer*—The radiation pyrometer for standardizing the thermal output of the panel shall be suitable for viewing a circular area 250 mm (10 in.) in diameter at a range of about 1.2 m (4 ft). It shall be calibrated over the operating black body temperature range in accordance with the procedure described in Annex A1.

TOP VIEW OF PILOT BURNER

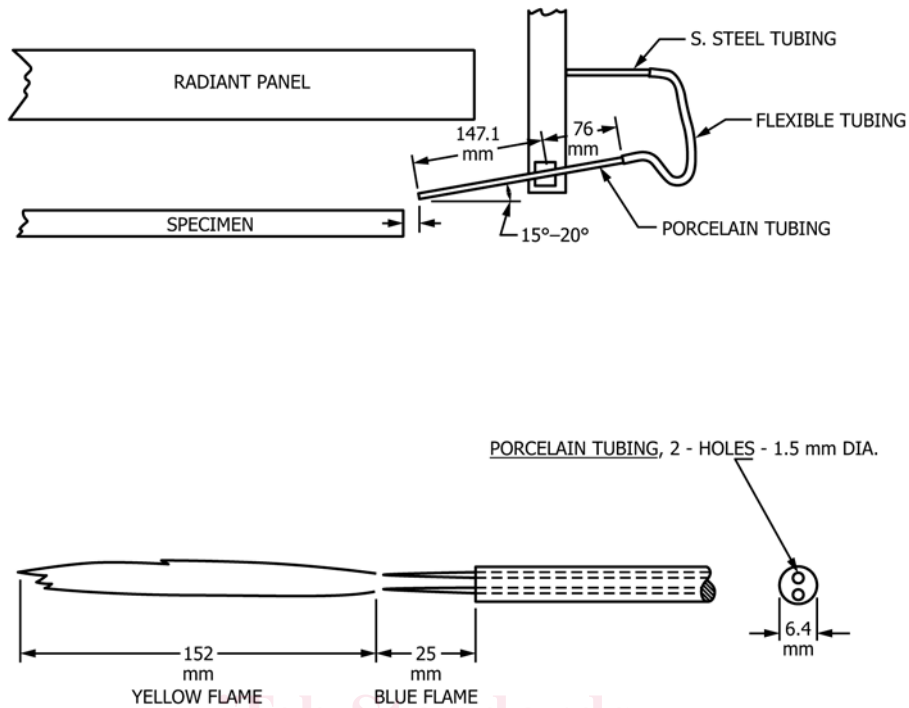


FIG. 3 Pilot Burner

6.1.10 *Portable Potentiometer*—The electrical output of the radiation pyrometer shall be monitored by means of a potentiometer provided with a millivolt range suitable for use with the radiation pyrometer described in 6.1.9. Alternatively, the data shall be permitted to be recorded with a computerized data acquisition unit, as discussed in 6.1.7.

6.1.11 *Timer*—The timer shall be calibrated to read to 0.01 min to record the time of events during the test.

7. Hazards

7.1 Safeguards shall be installed in the panel fuel supply system to guard against a gas air fuel explosion in the test chamber. Potential safeguards include, but are not limited to, one or more of the following: a gas feed cut-off activated when the air supply fails; a flame sensor directed at the panel surface that stops fuel flow when the panel flame goes out; and a heat detector mounted in contact with the radiant panel plenum that is activated when the panel temperature exceeds safe limits. Manual reset is a requirement of any safeguard system used.

7.2 The exhaust system must be so designed and operated that the laboratory environment is protected from smoke and gas. The operator shall be instructed on ways to minimize exposure to combustion products by following sound safety and industrial hygiene practices. For example, ensure that the exhaust system is working properly and wear appropriate clothing including gloves, safety glasses, breathing apparatus (when hazardous fumes are expected).

7.3 During this test, very high heat fluxes and high temperatures are generated that are capable of igniting some clothing

following even brief exposures. Precautions shall be taken to avoid ignitions of this type.

8. Test Specimens

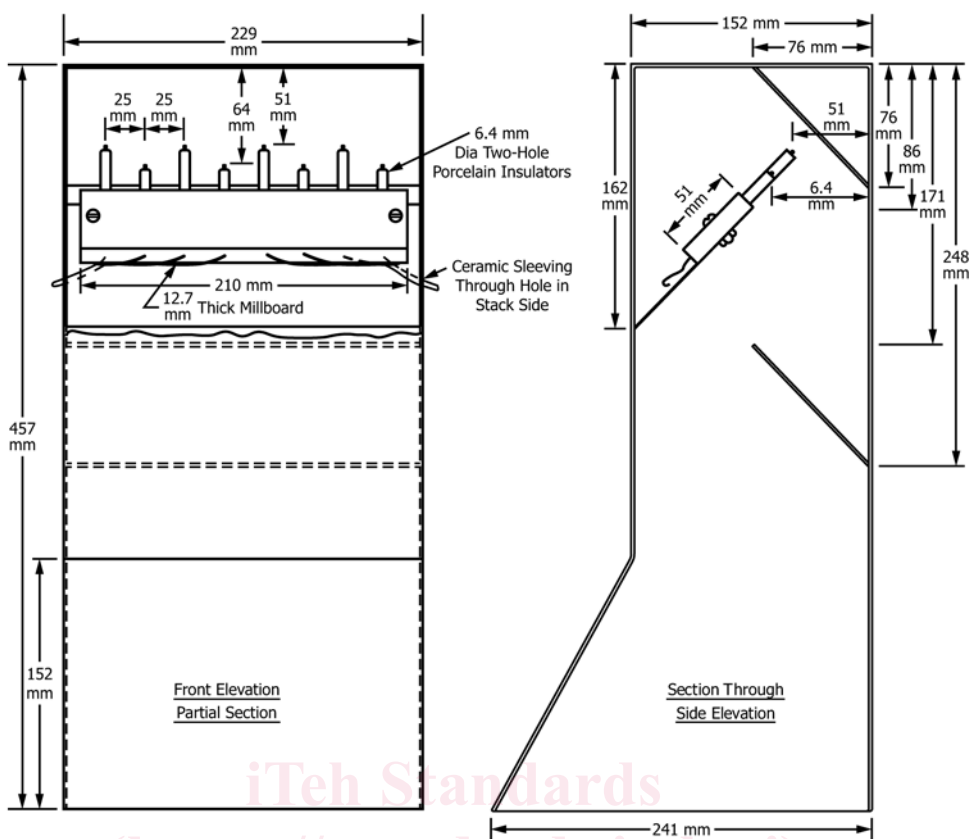
8.1 The test specimens shall be 150 by 460 by 25 mm (6 by 18 by 1.0 in.). Materials produced at less than 25-mm thickness shall be tested at the maximum thickness produced. Materials produced at less than 460 mm (18 in.) in length shall be mounted in series to provide a specimen of the proper length. No segment of the specimen shall be less than 150 mm (6 in.) in length.

8.2 After cutting or sawing to prepare test specimens, care shall be taken to remove dust and particles from the test specimen surface.

8.3 The back and sides of the test specimen shall be wrapped with aluminum foil, the shiny side against the test specimen, 0.05 mm (0.002 in.) nominally in thickness. High density inorganic reinforced cement board, nominally 6.4 mm (0.25 in.) in thickness, shall be used as backing. The test specimen shall be retained in the specimen holder by a nominally 150 by 460-mm (6 by 18-in.) sheet of nominally 25-mm (1-in.) 20-gage hexagonal steel wire mesh placed against the exposed face of the specimen. Molded skin or treated surfaces shall face the exposure.

NOTE 2—Aluminum foil is used against the specimen to prevent melting and destroying the back board/holders.

NOTE 3—Wherever inorganic reinforced cement board is specified, the material shall be nominally 6 mm (0.25 in.) thick, high density (1762 ± 80 kg/m<sup>3</sup> (110 ± 5 lb/ft<sup>3</sup>)) and uncoated.



Metric Equivalents

mm	in.	mm	in.	mm	in.
6.4	¼	76	3	229	9
12.7	½	86	3 ⅜	241	9 ½
25	1	152	6	248	9 ¾
51	2	171	6 ¾	457	18
64	2 ½	210	8 ¼		

FIG. 4 Thermocouple Mounting Arrangement

8.4 Four test specimens of each sample shall be tested. If one or more tests are deemed to be invalid, additional tests shall be conducted until four valid test results have been developed.

### 9. Conditioning

9.1 Condition the specimens for a minimum of 24 h at a temperature of  $23 \pm 3^\circ\text{C}$  ( $73 \pm 5^\circ\text{F}$ ) and a relative humidity of  $50 \pm 5\%$ .

9.2 Maintain the ambient conditions for the test apparatus at  $23 \pm 5^\circ\text{C}$ . Keep the test specimens in an enclosure at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  RH and take the test specimens out of the enclosure just before testing (so that testing is conducted within 30 minutes of the test specimen removal from the conditioning environment).

### 10. Procedure

10.1 Remove combustion product deposits from the thermocouples by brush cleaning or other effective method after each test.

10.2 At the start of each day, ignite the gas-air mixture passing through the radiant panel and allow the unit to heat for at least 0.5 h. Before each test, check the radiant output by means of the radiation pyrometer. Do this by placing the pyrometer in such a manner as to view a central panel area about 250 mm (10 in.) in diameter. Adjust the rate of air supply to between 750 and 800 ft<sup>3</sup>/h (5.9 and 6.3 L/s) and then adjust the fuel gas supply upwards from zero until it is just sufficient to produce a radiant output equal to that which would be obtained from a blackbody of the same dimensions operating at a temperature of  $670 \pm 4^\circ\text{C}$  ( $1238 \pm 7^\circ\text{F}$ ).

10.3 Turn on the recording potentiometer for measuring the stack thermocouple temperature.

10.4 Ignite the pilot and adjust it to give a flame 150 to 180 mm (6 to 7 in.) long with inner blue cones 25 mm (1.0 in.) in length.

10.5 Place the specimen holder containing the specimen into the supporting framework and start the timer. A maximum of 5 min shall lapse between the time the specimen is removed