Designation: D3675 – 17

Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source[1]

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 (ε) 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:*[2]

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:*[3]

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_s, 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.

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[1] 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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[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.

[3] 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)**[4, 5]

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^3/s (1200 ft^3/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 noncombustible 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^3/s (0.032 ft^3/min) of acetylene and 0.075 dm^3/s (0.16 ft^3/min) of air have been found to provide the desired flame.

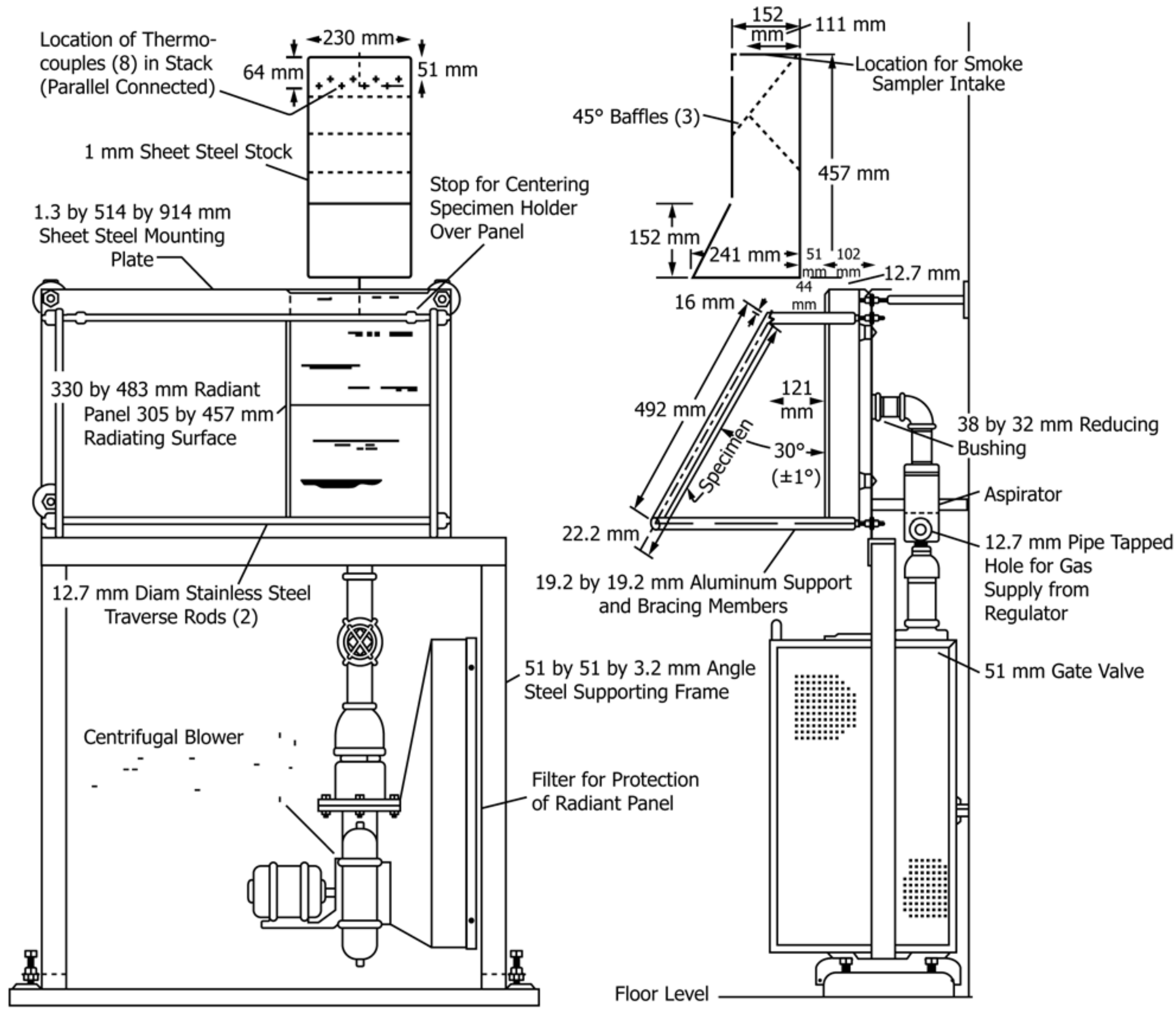
6.1.5 *Stack*—The stack shall be made from nominally 1.0-mm (0.040-in.) sheet steel with shape and dimensions as shown in Fig. 1. The position of the stack with respect to the specimen and radiant heat panel shall also comply with the requirements of Fig. 1.

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,

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[5] Also see Test Method E162.



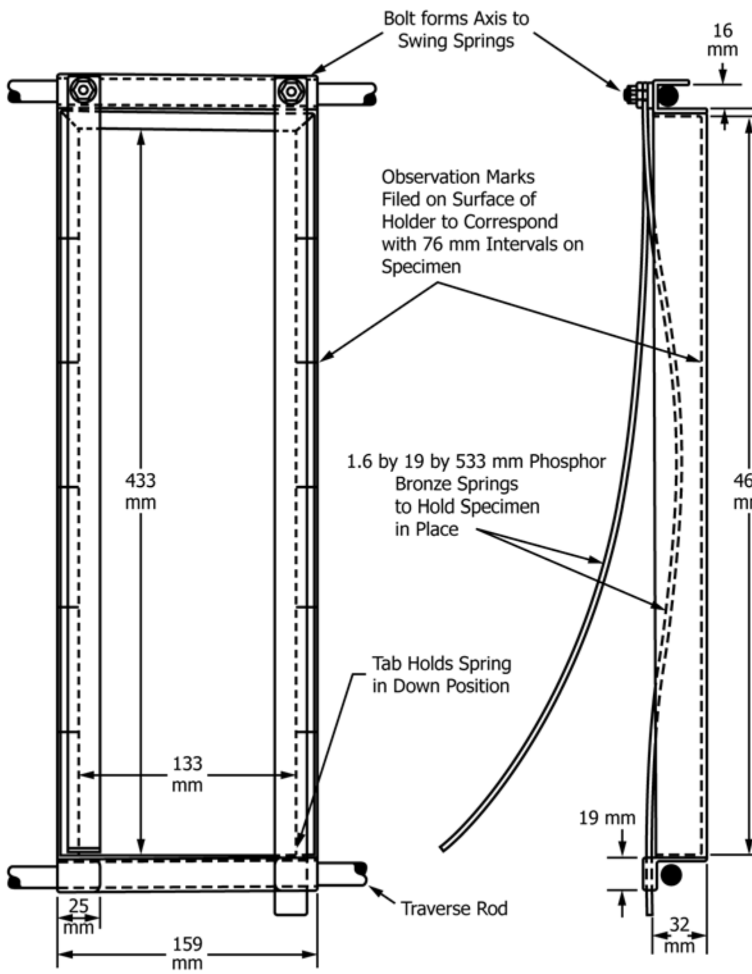
Metric Equivalents

mm	in.	mm	in.
1.0	0.040	152	6
12.7	½	241	9 ½
16.0	⅝	457	18
22.2	⅞	492	19 ⅜
44	1 ¾	19.1 by 19.	¾ by ¾
51	2	38 by 32	1 ½ by 1 ¼
64	2 ½	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 ⅛
111	4 ⅜	1.3 by 514 by 914	0.050 by 20 ¼ by 36
121	4 ¾		
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



Metric Equivalents

mm	in.	mm	in.
19.0	¾	159	6 ¼
25	1	433	17 ⅝
32	1 ¼	460	18 ⅛
76	3	1.6 by 19 by 533	1⁄16 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 ±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.

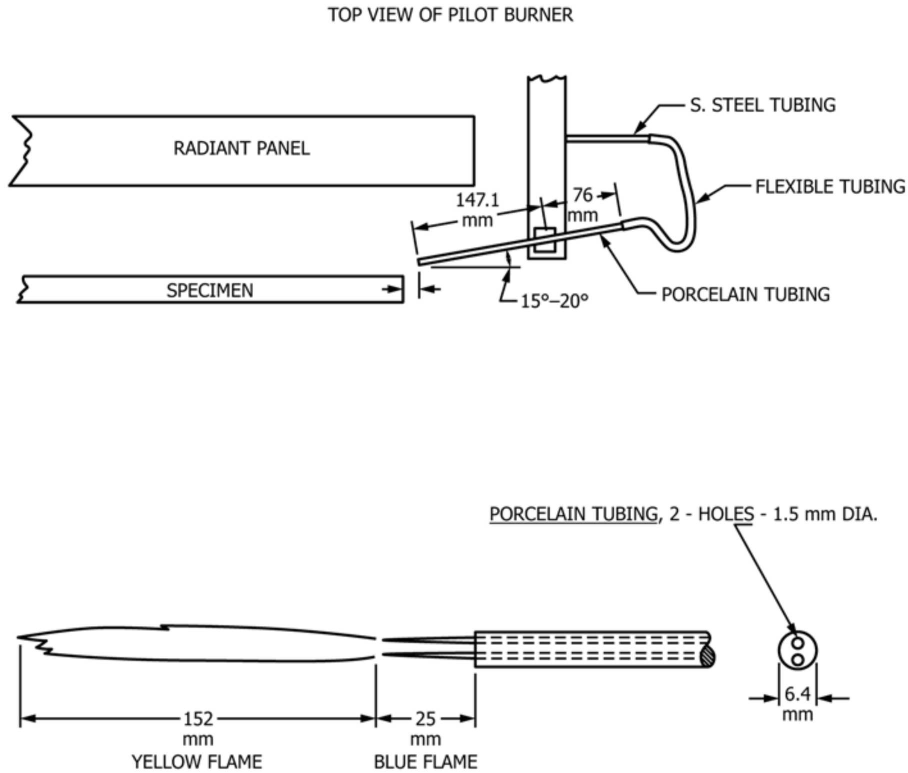


FIG. 3 Pilot Burner

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

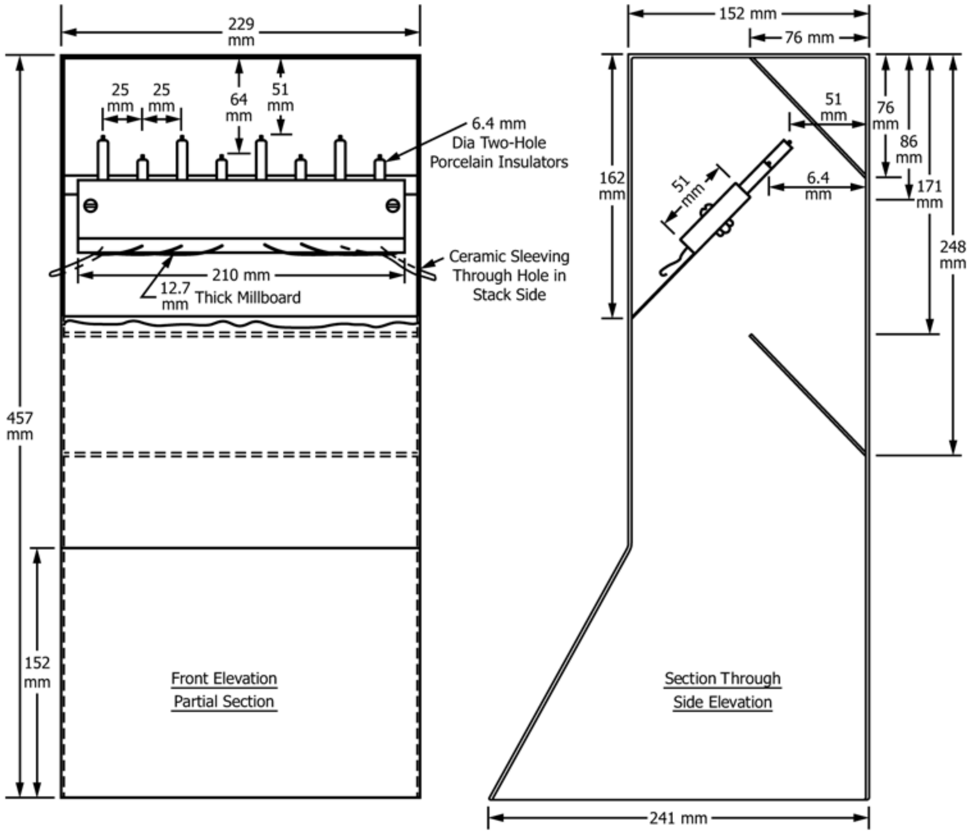
8.1 The test specimens shall be 150 by 460 by 25 mm (6 by 18 by 1.0 in.). Materials produced at less than 25-mm thickness shall be tested at the maximum thickness produced. Materials produced at less than 460 mm (18 in.) in length shall be mounted in series to provide a specimen of the proper length. 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^3 (110 ± 5 lb/ft^3)) 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 ± 3°C (73 ± 5°F) and a relative humidity of 50 ± 5 %.

9.2 Maintain the ambient conditions for the test apparatus at 23 ± 5°C. Keep the test specimens in an enclosure at 23 ± 2°C and 50 ± 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^3/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 ± 4°C (1238 ± 7°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 from the conditioning chamber until it is placed in position on the framework. During this time, place the specimen and holder in an appropriate vapor barrier jacket, removing it only when the specimen and holder are placed on the framework for the test. A polyethylene bag has been found suitable as a vapor barrier envelope.

10.6 Record the time of arrival of the flame at each of the 75-mm (3-in.) marks on the specimen holder. Also record the maximum temperature rise of the stack thermocouples.

10.7 Record any observations made of any behavior characteristics of a specimen that appear to be of interest.

10.8 *Exposure Time*—The test is completed when the flame front has progressed to the 375 mm (15 in.) mark on the specimen or after an exposure time of 15 min, whichever occurs earlier, provided the maximum temperature of the stack thermocouples is reached. After 15 minutes have elapsed and the maximum surface flame spread has been recorded, the test shall be discontinued if the stack temperature has increased by no more than 5°C over any five-minute measuring period after the initial 15-minute exposure period has elapsed. The maximum temperature shall be recorded as the maximum temperature measured before the test is discontinued.

10.9 If during the test of one or more of the test specimens, any of the behaviors identified in 10.9.1 through 10.9.5 occurs, the test is invalid. Then test an additional specimen of the identical preconditioned test specimens. Do not incorporate data obtained from invalid tests, yielding inadequate results, in the averaged data, but report the occurrence.

10.9.1 The specimen falls out of the specimen holder.

10.9.2 Most of the test specimen melts out of the specimen holder.

10.9.3 Explosive spalling forcefully displaces the specimen from the zone of controlled irradiance.

10.9.4 The test specimen swells sufficiently prior to ignition to touch the panel during combustion.

10.9.5 Materials exhibit rapid running or dripping of flaming material at any time during the test. This shall be assessed if flaming droplets fall away from the test samples at a rate of one drop per second (or faster), lasting for a continuous duration of ten seconds (or longer).

11. Calculation

11.1 Calculate the radiant panel index, I_s, of a specimen as the product of the flame spread factor, F_s, and the heat evolution factor, Q, as shown in:

$$I_s = F_s Q \tag{1}$$

where F_s and Q are as defined in 11.2 and 11.3.

11.2 *Calculation of* F_s—On linear graph paper, plot distance vertically against time of arrival of flame at each mark horizontally. For this purpose, assume that the flame starts at 0 in. (0 mm) at time 0 s, and plot this initial point also. Connect the six (or fewer) points with straight-line segments. If the upward slope of all the line segments becomes less steep, or remains constant, calculate F_s as shown in:

$$F_s = 1 + \frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} + \frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}} \tag{2}$$

where t_0 is conventionally 0, and t_3 ... t_{15} correspond to the time, in minutes, from initial specimen exposure until arrival of the flame front at the positions 3 ... 15 in. (76 ... 380 mm), respectively, along the length of the specimen.

11.2.1 If there are any segments where the slope increases eliminate the increase by drawing a straight line from the previous point to the succeeding point, thus "skipping" the point at which the slope increases (so, a "skip point" will always be located *below* the new line segment). Repeat this as often as necessary to eliminate slope increases. In some cases it will be necessary to skip 2, 3, or 4 consecutive points.

11.2.2 Points that are left below the final segmented curve are designated "skip points." Points on the curve are "curve points." If there are any points above the curve, this is an indication of errors. Using the equation for F_s given in 11.2, drop the two terms involving a single skip point, or the three to five terms involving two to four consecutive skip points, or both, and in each case replace them with the single new term $K/(T_f - T_b)$ where K is an integer related to the number of skip points, as follows:

Number of Skip Points	*K*
One single	4
Two consecutive	9
Three consecutive	16
Four consecutive	25

(Note that it is possible to have two, but no more, distinct groups of skip points.)

T_f = time in minutes at the first curve point following skip point.

T_b = time in minutes at the last curve point before a skip point.

11.2.3 Procedures equivalent to the preceding, for example computer programs, are equally valid.

11.3 Calculate Q as shown in:

$$Q = CT/\beta \tag{3}$$

where:

C = arbitrary constant 5.7, chosen to make results consistent with those obtained prior to the metrication of this calculation,

T = observed maximum stack thermocouple temperature difference in degrees Celsius between the temperature-time curve for the specimen and that for a similar curve of the inorganic reinforced cement board calibration specimen (see A1.2), and

β = mean stack thermocouple temperature rise for unit heat input rate of the calibration burner in degrees Celsius per kilowatt, a constant for the apparatus (see A1.2). (β will probably be found to lie between 0.6 and 1.2°F/Btu·min, or between 20 and 40°C/kW.)

NOTE 4—For those using English units, arbitrary constant C = 0.1, T shall be expressed in °F, and β shall be expressed in °F per Btu/min.

NOTE 5—The value of radiant panel index, I_s, is independent of the system of units used.

11.4 *Flame Fronts*—Sustained flame fronts are to be taken into account, for calculation purposes. Flashing is to be taken into account, for reporting purposes but not used for calculation purposes.

11.4.1 *Sustained Flame Fronts*—A sustained flame front is achieved at each 3-in. mark when a flame front advances to or beyond that 3-in. mark at such a rate that more than 3 s have passed since it reached the mark. Data obtained from sustained flame fronts shall be used for the calculation of the flame spread factor, F_s, as indicated in 11.2.

11.4.2 *Flame Fronts Not Sustained*—A flame front with a duration of 3 s or less represents flashing and not a sustained flame front. Such flames shall be reported as flashing but the data shall not be used in the calculation of the flame spread factor, F_s.

11.4.3 *Report of Flashing*—If flashing occurs, the fact shall be mentioned in the report and the word "Flashing" in parentheses shall follow the radiant panel index or I_s; it shall be reported in the form, for example, "I_s = 100 (Flashing)."

NOTE 6—When specimens of flexible cellular materials are prepared by cutting or sawing, it is not uncommon for small sections to remain hanging off the edge of the specimen. Such sections are often associated with very short random flaming, which is not related to the fire performance of the material.

11.5 Materials that have a tendency to exhibit rapid running or dripping of flaming material, either separately or in conjunction with a general flame front advance, due to melting and the steep inclination of the specimen during test, shall be noted as "Running (or Dripping) of Flaming Materials," and the time of occurrence shall be reported in addition to the regularly determined radiant panel index.

11.6 For materials in which flaming is rapid and is limited to the early part of the test exposure, it is possible for a slight temperature rise to remain undetected if recording is done intermittently. If the first test indicates such behavior, the test shall be deemed invalid, and additional tests shall be conducted by recording the stack thermocouple temperature at time intervals sufficiently small to ensure that no temperature rise values remain undetected; this can be achieved by taking recorder measurements every second or by using an appropriate data acquisition unit and computer.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the material tested, including type, source, manufacturer's code numbers, form, principal dimensions, color, previous history, etc.,

12.1.2 Type of test specimens, such as molded, slab, core, skin surface treated, etc., and thickness,

12.1.3 Conditioning procedure used. A justification shall be given if the procedure does not comply with that specified in 9.1,

12.1.4 Number of specimens tested, including an explanation of any invalid test results,

12.1.5 Exposure time and whether the specimen was completely destroyed or was exposed for 15 min,

12.1.6 Average value of I_s, and range of I_s values, for each set of specimens and range, and

12.1.7 Designation of "Flashing" and "Running (or Dripping) of Flaming Material" where applicable, including time of occurrence and any other visual burning characteristics deemed relevant.

13. Precision and Bias[6]

13.1 These precision data are based on tests of six materials by eleven laboratories in the 1970s. Sufficient quantities of each of the six materials were prepared in one laboratory and sent to the participating laboratories. The repeatability and reproducibility results therefore do not include "material preparation" components of variation. Four replicate determinations were conducted on each material. Due to a shortage of materials any individual laboratory tested only four of the six materials. The six materials are as follows:

13.1.1 Urethane, 1 in. thick.

13.1.2 Neoprene, 1 in. thick.

13.1.3 Neoprene, ½ in. thick.

13.1.4 Polyester urethane, 1 in. thick.

13.1.5 Polyether urethane, 1 in. thick.

13.1.6 PVC acrylonitrile butadiene copolymer, ½ in. thick.

The approximate range of test values obtained on these materials for each test response are as follows:

$$\frac{F_s,\ \text{min}^{-1}}{1-92}\quad\frac{Q,\ \text{Btu min}^{-1}}{5-21}\quad\frac{I_s,\ \text{Btu min}^{-2}}{7-1950}\tag{4}$$

Precision is expressed in relative terms (2S%, D2S%).

13.2 *Repeatability*—Two test results, reported as the average of four replicates, do not differ significantly unless their difference as a percent of their average value exceeds the following percentages:

$$\frac{F_s}{31\ \%}\quad\frac{Q}{43\ \%}\quad\frac{I_s}{70\ \%}\tag{5}$$

13.3 *Reproducibility (Multilaboratory)*—Two test results, reported as the average of four replicates, do not differ significantly unless their difference as a percent of their average value exceeds the following percentages:

$$\frac{F_s}{174\ \%}\quad\frac{Q}{104\ \%}\quad\frac{I_s}{192\%}\tag{6}$$

13.4 The percent error of these responses is larger than usually desired. However, this test can distinguish between materials which characteristically differ by a large amount.

14. Keywords

14.1 beta factor; I_s; radiant panel; radiant panel index; surface flammability

[6] Supporting data are available from ASTM Headquarters. Request RR:D11-1014 (September 1978).

ANNEX

(Mandatory Information)

A1. PROCEDURE FOR CALIBRATION OF APPARATUS

A1.1 Radiation Pyrometer

A1.1.1 Calibrate the radiation pyrometer by means of a conventional commercial blackbody enclosure placed within a furnace and maintained at a uniform temperature of 670 ± 5°C (1238 ± 10°F). A typical blackbody enclosure consists of a closed Chromel metal cylinder with a small sight hole in one end. The radiation pyrometer is sited upon the opposite end of the cylinder from that where a thermocouple indicates the blackbody temperature. Perform the calibration by placing the thermocouple within a drilled hole and in good thermal contact with the blackbody.

A1.2 Stack Thermocouples

A1.2.1 With the panel at operating temperature and the exhaust blower producing a steady stack velocity (suitable for conducting the tests), note the temperature of the stack thermocouples. Initial positioning of the exhaust hood system shall be made so as to maintain the operating stack thermocouple temperature within the range from 180 to 230°C (356 to 446°F) when no specimen is in position. Place an inorganic reinforced cement board specimen in position (with the specimen holder to be used during the tests), ignite the pilot burner, adjust the flame to a 150 to 180-mm (6 to 7-in.) length with 25-mm (1.0-in.) inner blue cones. Record the increase in temperature measured by the stack thermocouple over the 15-min interval by obtaining temperature data at intervals not exceeding 5 s, and preferably at even shorter intervals. Use this time-temperature curve as a base for measurement of stack thermocouple temperature rise in the testing of materials.

NOTE A1.1—The use of millboard backing during stack thermocouple calibration is inconsistent with the omission of the millboard backing during the test procedure.

A1.2.2 Place an inorganic reinforced cement board specimen, without backing, in the test position (with the specimen holder to be used during the tests), and note the ensuing equilibrium temperature of the stack thermocouples which will be used as a base temperature for the following procedure: Prepare a multiported diffusion (no premixed air) burner from a 300 to 380-mm (12 to 15-in.) length of nominally 6 mm (¼-in.) standard wrought iron or steel pipe capped at one end and containing ten 1.8 ± 0.2 mm (0.070 ± 0.008 in.) diameter radial holes spaced 16 ± 1 mm (⅝ ± 0.04 in.) on centers along a line parallel to the axis of the pipe. Place the center-line of the pipe burner in horizontal position 25 ± 2 mm (1 ± 0.1 in.) (measured along the specimen surface) below the upper exposed edge of the inorganic reinforced cement board specimen. The pipe wall shall be in contact with both side edges of the specimen holder so that the portion of the pipe containing the burner holes is centered with respect to the specimen. The axes of the burner holes shall be vertical causing flames from the burner to impinge at or near the top of the inorganic reinforced cement board specimen. The type and orientation of the yellow diffusion flames produced are comparable to the flames emitted from a burning specimen. Ignite the pilot burner and adjust it in the manner described in 6.1.4. Record the maximum stack thermocouple temperature rise above the previously defined base for each of several gas flow rates to the burner, allowing a minimum of 10 min at each flow rate for stack temperature stabilization. The gas supplied to the calibration burner shall be manufactured methane, or natural gas, or combinations of these gases. The gas flow rate to the calibration burner should be measured by means of a calibrated flowmeter. Use the higher (gross) heating value of the gas to convert the gas flow rates to heat input rates. Moisture, temperature, and pressure corrections shall be applied, when applicable, to convert the gas flow rates and the higher (gross) heating value of the gas to a dry basis at a standard temperature of 16°C (60°F) and a standard pressure of 101 kPa (30.0 in. Hg). Plot the maximum stack thermocouple temperature rise in degrees Celsius (Fahrenheit) as a function of the corresponding measured heat input in kilowatts (Btu per minute). The value of β used in the radiant panel index or I_s formula in 11.3 is based on the ratio of a temperature rise to the heat input required to produce it. This shall be measured at the level required to produce a temperature rise of 100°C (180°F). For those using degrees Celsius β is the simple ratio of a temperature rise of 100°C to the heat input in kilowatts producing it. For those using degrees Fahrenheit for T in 11.3, β is the ratio of a temperature rise of 180°F to the heat input in Btu per minutes producing it.

A1.3 Calibration Check

A1.3.1 The proper calibration of the radiation pyrometer of a blackbody temperature of 670°C (1238°F) as described in 6.1.9 and A1.1.1 is important. Where facilities for performing such a calibration are not available to laboratories equipped with the radiant panel test apparatus, a check calibration service exists at the Building and Fire Research Laboratory of the National Institute of Standards and Technology, Gaithersburg, MD, 20899. Other commercial services also exist.

APPENDIXES

(Nonmandatory Information)

X1. Commentary

There are several different test methods for assessing the surface flammability of materials. However, these tests are often intended for the purpose of evaluating interior finish and other building materials. Such test methods are often not suitable for testing flexible cellular materials, which require specific test method characteristics. However, this test method was developed as a modification of Test Method E162 intended specifically for fire testing of flexible cellular materials. Test Method E162 itself was developed by the National Bureau of Standards (now National Institute of Standards and Technology) to obtain surface flame spread information based on a radiant heat source, as an alternative to the traditional Steiner tunnel test (Test Method E84). Later, in the 1980s, the National Institute of Standards and Technology developed a more advanced test method for assessing material flammability and flame spread, as well as fundamental material fire properties (**5, 6**) (Test Methods E1317 and E1321); however the apparatus (known as the Lateral Ignition and Flame Spread Test, or LIFT) has been used primarily by the maritime industry, and no testing methodologies specific for flexible cellular materials have been developed to date.

X2. MELTING GENERATING FLAMING MOLTEN MATERIAL

X2.1 Subsection 10.9, and its subsections, explain that, if during the conduction of a test, materials exhibit rapid running or dripping of flaming material, the test is to be deemed invalid. This appendix section further discusses the rationale for this requirement.

X2.2 Materials that melt rapidly during the test cannot adequately be assessed with Test Method D3675, in view of the fact that it is not possible to determine with precision the time at which the flame front reaches each of the marks on the specimen holder. Historically, some materials exhibiting this type of behavior, received misleading, favorable Radiant Panel Index (RPI) values.

X2.3 If materials undergo melting and also generate flaming droplets (or flaming molten material), such materials are deemed to present fire safety concerns because the burning material can possibly generate flames that spread to a nearby substrate/target, and, thus, cause the fire to move beyond the object of origin. This phenomenon has been discussed in research at NIST (Bundy and Ohlemiller, 2003, 2004) (**7, 8**), which showed that flaming melt flow can reach the floor or spread on a surface and cause radiant ignition of remote objects. In such cases, the radiant panel test is considered invalid (see 10.9). When tests are invalid no radiant panel index value can be assigned to the material.

X2.4 The fire hazard associated with materials that undergo rapid melting, and thus cannot be tested appropriately using Test Method D3675, but generate no flaming droplets or flaming materials, may be different from that of materials that both melt and generate flaming droplets.

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SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D3675 – 14) that may impact the use of this standard. (May 1, 2017)

(1) Added Appendix X2.

Committee D20 has identified the location of selected changes to this standard since the last issue (D3675 – 14) that may impact the use of this standard. (May 1, 2016)

(1) Revised Fig. 3.