



Designation: D 3675 – 9801

Standard Test Method for Surface Flammability of Flexible Cellular Materials Using A Radiant Heat Energy Source¹

This standard is issued under the fixed designation D 3675; 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 ~~covers~~ describes the measurement of surface flammability of flexible cellular materials.

1.3 ~~This standard should be used to measure~~ measures and describes the response of materials, products, or assemblies to heat and flame under controlled conditions and ~~should not be used to describe~~ conditions, but does not, by itself, incorporate all factors required for fire hazard or appraise the fire-hazard or fire-risk fire risk assessment of the materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire-hazard assessment or a fire-risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard or fire risk of a particular end use.

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 of products and materials is inherently hazardous, and adequate safeguards for personnel and property shall be employed in conducting these tests. This test method may involve hazardous materials, operations and equipment. Specific information about hazards is given in Section 7.

NOTE 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

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. Current edition approved ~~March~~ August 10, 1998; 2001. Published ~~January~~ 1999; October 2001. Originally published as D 3675 – 78. Last previous edition D 3675 – 958.

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

E 162 Test Method for Surface Burning Characteristics of Building Materials²
E 162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source²
E 176 Terminology of Fire Standards²
E 1317 Test Method for Flammability of Marine Surface Finishes²
E 1321 Test Method for Determining Material Ignition and Flame Spread Properties²
E 1546 Guide for Development of Fire-Hazard-Assessment Standards²
2.2 ISO Standards:³
ISO 13943 Fire Safety— Vocabulary

3. Summary Terminology

3.1 Definitions:

3.1.1 For definitions of Test Method

3.1 This terms used in this test method, refer to the terminology contained in Terminology E 176 and ISO 13943. In case of measuring surface flammability conflict, the definitions given in Terminology E 176 shall prevail.

3.1.2 *flame front, n*—the leading edge of flexible cellular materials employs a radiant panel heat source consisting flame propagating through a gaseous mixture or across the surface of a 300 by 460-mm (12 by 18-in.) panel in front liquid or solid.

3.2 Definitions of which an inclined 150 by 460-mm (6 by 18-in.) specimen Terms Specific to This Standard:

3.2.1 *flashing, n*—flame fronts of the material is placed. The orientation three seconds or less in duration.

3.2.2 *radiant panel index, I_r, n*—the product of the specimen is such that ignition is forced near its upper edge and the flame front progresses downward.

3.2 Factors derived from the rate of progress of the flame front spread factor, F , and heat liberated by the material under test are combined to provide a flame spread index. 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.

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

45.1 This test method is intended for measurements on use when measuring surface flammability of flexible cellular materials whose surfaces may be exposed to fire. ~~It~~ 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 made on 150 by 460-mm (6 by 18-in.) 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.

45.2 The rate at which flames will travel along surfaces depends upon the physical and thermal properties of the material, its method of 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.

4.3 In⁵

5.3 Test Method E 162 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 E 162 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 E 162.

5.4 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, it may is not be always possible by or

² Annual Book of ASTM Standards, Vol 04.07.

³ For additional information refer to the following:

(1) Robertson, A. F., Gross, D., and Loftus, J., "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source," *Proceedings*, ASTM, Vol

³ Available from International Standardization Organization, P.O. Box 56, 1956, pp. 1437-1453.

(2) Robertson, A. F., "Surface Flammability Measurements by the Radiant Panel Methods," *ASTM STP 344*, ASTM, 1962, pp. 33-46.

(3) Gross, D. and Loftus, J. J., "Surface Flame Propagation on Cellulosic Materials Exposed to Thermal Radiation," *Journal of Research*, NBS, Vol 67C, 1963, pp. 251-258.

(4) Magee, R. S. and McAlevy III, R. F., "The Mechanism of Flame Spread," *Journal of Fire and Flammability*, Vol 2, 1971, pp. 271-297. CH-1211; Geneva 20, Switzerland.

⁴ Also see Test Method E 162.

⁴ The numbers in bold brackets refer to the list of references at the end of this standard.

⁵ Supporting data are available from ASTM Headquarters. Request RR: D11-1014.

⁵ Also see Test Method E 162.

from this test to predict changes in the performance fire-test-response characteristics measured. Therefore, the results are strictly valid only for the fire test exposure conditions described in this procedure.

4.4 If

5.5 If the test results obtained by this test method are to be considered in the total as part of an overall assessment of fire hazard in a building or structure, then all pertinent established criteria for fire hazard assessment developed by ASTM Committee E-5 must be included in the criteria, concepts and procedures incorporated into Guide E 1546 shall be taken into consideration.

56. Apparatus

56.1 The apparatus shall be essentially as shown in Fig. 1 and Fig. 2 and shall include the following:

56.1.1 *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. 2) with a venturi-type aspirator for mixing gas and air at approximately atmospheric pressure; a centrifugal blower, or equivalent, to provide 47 dm³/s (100 ft³/min) 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.

56.1.2 *Specimen Holder*—The specimen holder shall conform in shape and dimension to Fig. 3 and be constructed from heat-resistant chromium steel, or other suitable non-combustible material which will no 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.

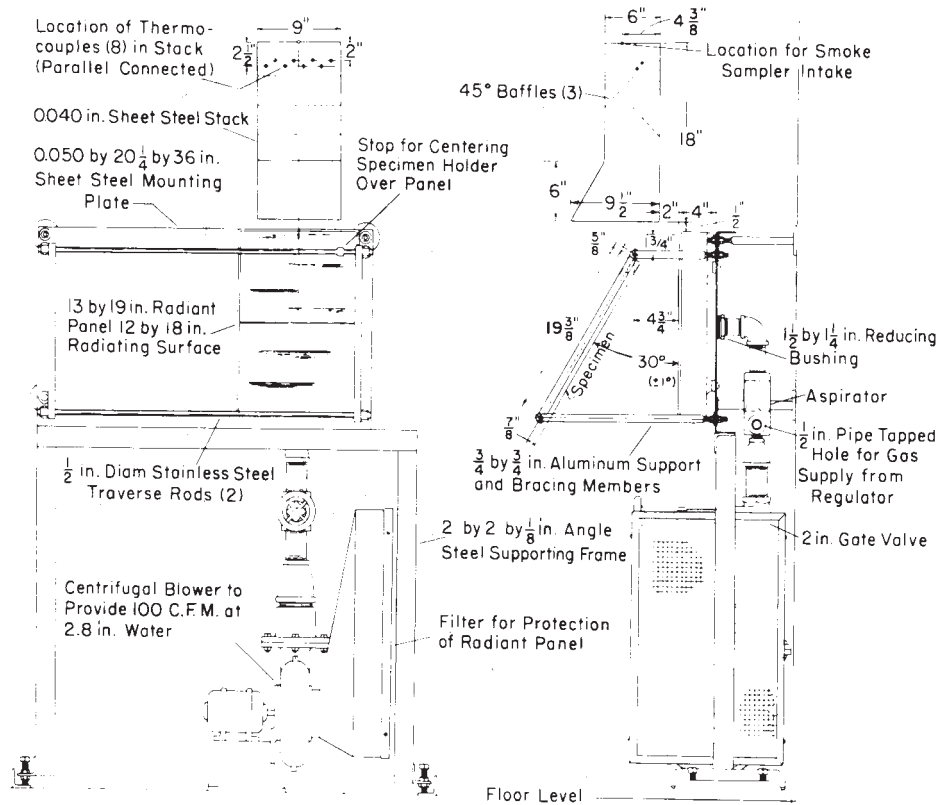
56.1.2.1 The calibration process (see A1.2) shall be conducted with the specimen holder to be used in the tests to ensure that the physical characteristics of the construction material do not affect the test results.

6.1.3 *Framework for Support of the Specimen Holder*—The framework shall have two transverse rods of stainless steel, each about 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 ~~should~~ 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. 2.

56.1.4 *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. 4). 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



FIG. 1 Radiant Panel Flame Spread Test Equipment



Metric Equivalents

in.	mm	in.	mm
0.040	1.0	6	152
1/2	12.7	9 1/2	241
5/8	16.0	18	457
7/8	22.2	19 3/8	492
1 3/4	44	3/4 by 3/4	19.2 by 19.2
2	51	1 1/2 by 1 1/4	38 by 32
2 1/2	64	12 by 18	305 by 457
2.8	71	13 by 19	330 by 483
4	102	2 by 2 by 1/8	51 by 51 by 3.2
4 3/8	111	0.050 by 20 1/4 by 36	13 by 514 by 914
4 3/4	121		

100 cfm = 47.21 litres/s

FIG. 2 Details of Construction of Test Equipment

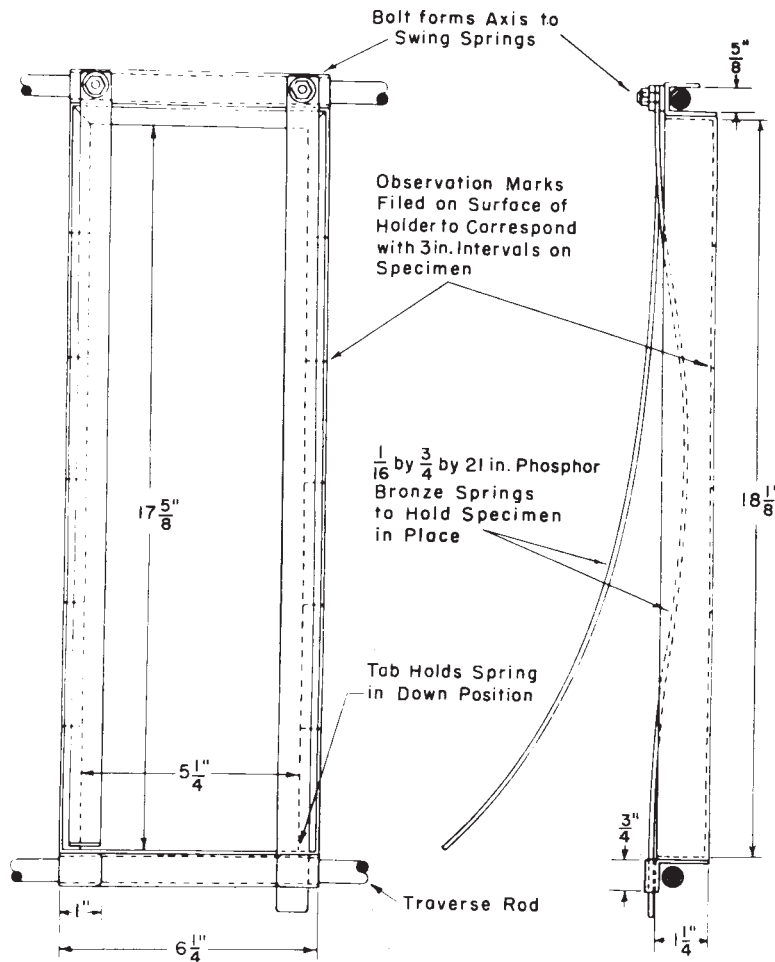
specimen with the outlet end of the burner spaced 32 ± 2 mm (1.25 ± 0.1 in.) from the specimen (see Fig. 4). The pilot shall provide a 150 to 180-mm (6 to 7-in.) flame of acetylene gas premixed with air in an aspirating type fitting. ~~Acetylene has been found satisfactory for this purpose.~~ Properly adjusted, the pilot flame ~~should~~ 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 dm³/s (0.032 ft³/min) of acetylene and 0.075 dm³/s (0.16 ft³/min) of air have been found to provide the desired flame.

56.1.5 Stack—The stack shall be made from nominally 1.0-mm (0.040-in.) sheet steel with shape and dimensions as shown in Fig. 2. The position of the stack with respect to the specimen and radiant heat panel shall also comply with the requirements of Fig. 2.

56.1.6 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. 2 and Fig. 5. ~~Each junction~~ The thermocouples shall be formed by fusing Chromel-Alumel Type K, shielded against high heat with insulation resisting up to 1200°C (2170°F), and with wire gages in the end range of a twisted pair of chromel and alumel wires of 0.5-mm (0.02-in.) 0.36–0.51 mm (0.14–0.20 in.; 30 AWG–24 AWG) diameter. The ~~wiring~~ mean stack thermocouple temperature rise for unit heat input rate of the calibration burner, β , shall be determinesued periodically for the specific test apparatus, using the procedure in a manner that adequately protects those segments subjected to elevated temperatures.

5.1.7 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 ~~5~~ 6.1.6. Alternatively, a



Metric Equivalents

in.	mm	in.	mm
$\frac{3}{4}$	19.0	$6\frac{1}{4}$	159
1	25	$17\frac{5}{8}$	433
$1\frac{1}{4}$	32	$18\frac{1}{8}$	460
3	76	$\frac{1}{16}$ by $\frac{3}{4}$ by 21	1.6 by 19 by 533
$5\frac{1}{4}$	133		

FIG. 3 Specimen Holder

computerized data acquisition system shall be permitted to be used. The recorder data acquisition system shall give a continuous have facilities to record the temperature output from the thermopile. The data acquisition system shall print at time intervals have an accuracy of $\pm 0.01\%$ 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).

56.1.8 Hood—A hood with exhaust blower placed over the stack is required. The blower should shall produce a velocity that adequately exhausts all of the smoke and combustion gases. The blower shall be capable of producing a velocity of 0.5 m/s (100 ft/min, 30 m/min) at the top of the stack with the radiant panel not operating, or approximately 1.3 m/s (250 ft/min) with the radiant panel at operating temperature. The velocity is not critical for flame spread measurements provided a stack thermocouple calibration is performed (see 6.1.6 and A1.32) for the established test conditions. The hood surfaces should shall clear the top and sides of the stack by a minimum of 250 mm (10 in.) and 190 mm (7.5 in.) respectively.

56.1.9 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.

56.1.10 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 56.1.9. Alternatively, the data shall be permitted to be recorded with a computerized data acquisition unit, as discussed in 6.1.7.

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

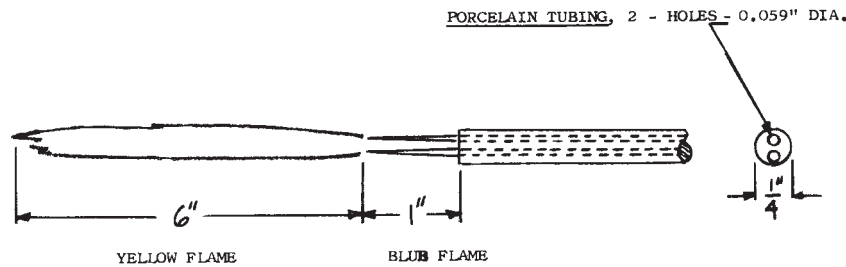
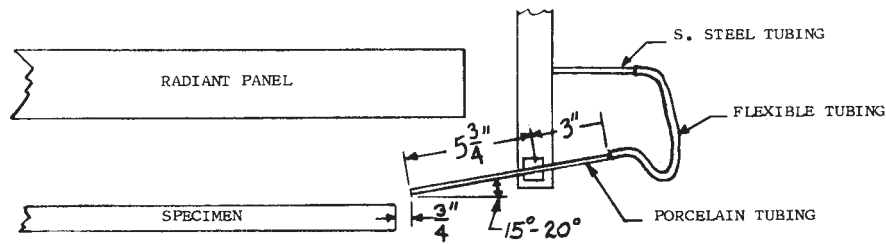


FIG. 4 Pilot Burner

6. Test Specimens

6.1 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.

6.2 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.) in thickness. Insulation board, 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 150 by 460-mm (6 by 18-in.) sheet of 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.

6.3 At least four test specimens of each sample shall be tested.

7. Conditioning

7.1 Condition Hazards

7.1 Safeguards shall be installed in the specimens for 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 $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$) 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).

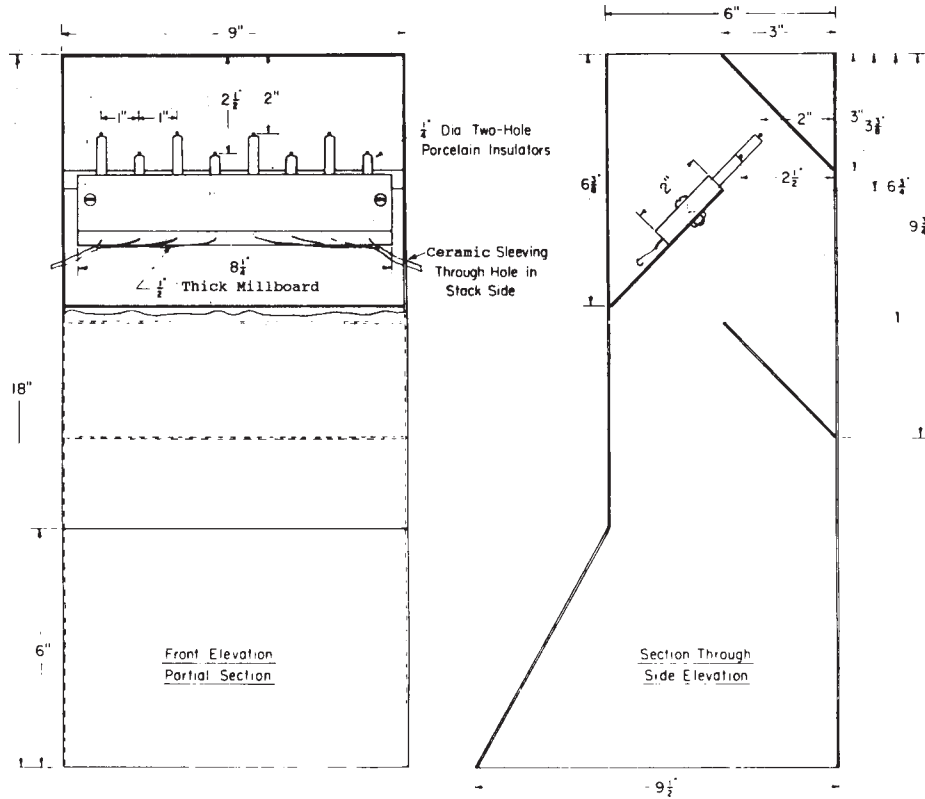
7.3 During this test, very high heat fluxes and high temperatures are generated that are capable of 50 ± 5% igniting some clothing following even brief exposures. Precautions shall be taken to avoid ignitions of this type.

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.) in thickness. High density inorganic reinforced cement board, 6.4 mm (0.25 in.) in thickness, shall be used as



Metric Equivalents

in.	mm	in.	mm	in.	mm
1/4	6.4	3	76	9	229
1/2	12.7	3 3/8	86	9 1/2	241
1	25	6	152	9 3/4	248
2	51	6 3/4	171	18	457
2 1/2	64	8 1/4	210		

FIG. 5 Thermocouple Mounting Arrangement

backing. The test specimen shall be retained in the specimen holder by a 150 by 460-mm (6 by 18-in.) sheet of 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—Wherever inorganic reinforced cement board is specified, the material shall be nominally 6 mm (0.25 in.) thick, high density (1762 ± 80 kg/m³; 110 ± 5 lb/ft³) and uncoated.

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 %.

10. Procedure

8.1 Remove objectionable

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

8.2 Ignite

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 placed in such a manner as to view a central panel area about 250 mm (10 in.) in diameter. Adjust the rate of gas supply to maintain the 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).

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

810.4 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.

810.5 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.

810.6 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.

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

810.8 *Exposure Time*—The test is completed when the flame front has progressed to the full length of 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.

10.9 If during the test of one or more of the test specimens, any of the following unusual behavior occurs: (1) the specimen falls out of the specimen holder, (2) most of the test specimen melts out of the specimen holder, (3) explosive spalling forcefully displaces the specimen from the zone of controlled irradiance; or (4) the test specimen swells sufficiently prior to ignition to touch the panel during combustion; the test is invalid. Then test an additional specimen of the identical preconditioned test specimens. Do not incorporate data obtained from the tests noted above, yielding inadequate results, in the averaged data, but report the occurrence.

11. Calculation

911.1 Calculate the flame spread 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 follows: shown in:

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

where F_s and Q are as defined in 9.2 11.2 and 9 11.3.

911.2 *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 min, 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 follows: 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.

911.2.1 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 may be necessary to skip 2, 3, or 4 consecutive points.

911.2.2 Points that are left below the final segmented curve are designated “skip points.” Points on the curve are “curve points.” ~~There should be no~~ If there are any points above the curve, this is an indication of errors. Using the equation for F_s given in 9 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.

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

911.3 Calculate Q as follows: 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 23—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 4—The value of radiant panel index, I_r , is independent of the system of units used.

911.4 *Flame Fronts Not Sustained*—All flame fronts, however temporary, are to be taken into account, for reporting purposes.

911.4.1 *Rapid Flame Spread*—If flame spreads from any of the 3-in. marks to the next in 3 s or less, the fact ~~should~~ shall be mentioned in the report and the word “Flashing” in parentheses ~~should~~ shall follow the ~~flame spread index; radiant panel index or I_r~~ ; it ~~should~~ shall be reported in the form, for example, “ $I_r = 100$ (Flashing).” However, flaming of a short duration, and associated with small portions of the specimen surface, shall not be used in the calculation of I_r .

NOTE 5—When specimens of flex = 100 (Fiberglass cellular materials are prepared by cutting or sawing, it is not uncommon for small sections to remain hanging) off the edge of the specimen.²² Such sections are often associated with very short random flaming, which is not related to the fire performance of the material.

911.5 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 ~~should~~ shall be reported in addition to the regularly determined flame spread radiant panel index.

911.6 For materials in which ~~the~~ flaming is rapid and is limited to the early part of the test exposure, it is possible for a slight temperature rise ~~may~~ to remain undetected if recording is done ~~intermittently~~ (for example, at 15-s intervals). Continuous intermittently. If the first test indicates such behavior, the test shall be deemed invalid, and additional tests shall be conducted by recording of 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.

102. Report

102.1 Report the following information:

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

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

102.1.3 Conditioning procedure used. A justification shall be given if ~~different from~~ the procedure does not comply with that specified in 7.9.1,

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

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

~~10.1.6 Average flame spread index~~

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

102.1.7 Designation of ~~“Flash Potential” and “Running~~ “Flashing” and “Running (or Dripping) of Flaming Material” where applicable, including time of occurrence and any other visual burning characteristics deemed relevant.

113. Precision and Bias ⁶

113.1 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:

113.1.1 Urethane, 1 in. thick.

113.1.2 Neoprene, 1 in. thick.

113.1.3 Neoprene, ½ in. thick.

113.1.4 Polyester urethane, 1 in. thick.

113.1.5 Polyether urethane, 1 in. thick.

113.1.6 PVC acrylonitrile butadiene copolymer, ½ in. thick.

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

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

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

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

143.2 *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:

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

143.3 *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:

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

143.4 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.

124. Keywords

124.1 beta factor; ~~flame spread index~~; I_s ; radiant panel; radiant panel index; surface flammability

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 $670 \pm 5^\circ\text{C}$ ($1238 \pm 10^\circ\text{F}$). ~~The A typical blackbody enclosure may consist~~ consists of a closed Chromel metal cylinder with a small sight hole in one end. ~~Sight the~~ 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 ~~an established a steady~~ a steady stack velocity (suitable for conducting the tests), note the temperature of the stack thermocouples. ~~It is recommended that initial~~ 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 ~~insulation 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. ~~Continuously, record~~ 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, ~~with a 13-mm (1/2-in.) asbestos millboard backing 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 (1/4-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 ($5/8 \pm 0.04$ 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 ~~4~~ 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 ~~should~~ 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 ~~flame spread radiant panel~~ index or I_r formula in ~~9.3~~ 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 ~~9~~ 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 ~~5~~ 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 ~~may be secured upon request to service exists at the Center for Building and Fire Research, Laboratory of the National Institute of Standards and Technology, Washington, D.C. 20025. Gaithersburg, MD, 20899.~~ Other commercial services also exist.

APPENDIX

(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 E 162 intended specifically for fire testing of flexible cellular materials. Test Method E 162 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 E 84). 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 E 1317 and E 1321); 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.

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- (4) Magee, R. S. and McAlevy III, R. F., "The Mechanism of Flame Spread," *Journal of Fire and Flammability*, Vol 2, 1971, pp. 271-297.
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SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D-20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

D 3675–01:

- (1) Updated caveats for fire test response standards in Scope.
- (2) Removed non-mandatory language throughout the standard.
- (3) Added section on Terminology.
- (4) Added background information and references to Significance and Use.
- (5) Added tolerances throughout section on Apparatus.
- (6) Added provisions for computerized data acquisition system.
- (7) Added specifications for exhaust blower in 6.1.8.
- (8) Added section on Hazards.
- (9) Added section 8.2 on care when cutting and sawing to prepare test specimens.
- (10) Updated backing material for test specimens.
- (11) Added 10.9 on invalid test results.
- (12) Clarified calculations when short random localized flashing occurs.
- (13) Added Note explaining short random flashes.
- (14) Added Note on millboard backing, A1.2.1.
- (15) Updated information in calibration service, A1.3.1.
- (16) Added background information in new Appendix Appendix X1.
- (17) Changed definition of “flame spread index” to “radiant panel index” or I_{r} , consistent with Test Method E 162.
- (18) Replacement of term “flame spread index” by “radiant panel index” or I_{r} .

D 3675–98:

- (1) Added ISO equivalency statement.
- (2) Amended last sentence of A1.2.2.
- (3) Added Note-2.3 to-9.3 11.3 for use of English units.

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