



Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source¹

This standard is issued under the fixed designation E162; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This fire-test-response standard describes the measurement of surface flammability of materials. It is not intended for use as a basis of ratings for building code purposes (see [Appendix X1](#)).

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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 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 hazard is given in Section .

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

2. Referenced Documents

2.1 *ASTM Standards*:²

[C1186 Specification for Flat Fiber-Cement Sheets](#)

[C1288 Specification for Discrete Non-Asbestos Fiber-](#)

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

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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.

[Cement Interior Substrate Sheets D3675 Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source](#)
[E84 Test Method for Surface Burning Characteristics of Building Materials](#)
[E176 Terminology of Fire Standards](#)
[E1546 Guide for Development of Fire-Hazard-Assessment Standards](#)
2.2 *ISO Standards*³
[ISO 13943 Fire Safety—Vocabulary](#)

3. Terminology

3.1 *Definitions*—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.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *flashing, n*—flame fronts of 3 seconds or less in duration.

3.2.1.1 *Discussion*—All flame fronts, however temporary, are to be taken into account.

3.2.2 *radiant panel index, I_s, n*—the radiant panel index is 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 materials employs a radiant heat source consisting of a 12 by 18-in. (305 by 457-mm) panel, in front of which an inclined 6 by 18-in. (152 by 457 mm) 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 A factor derived from the rate of progress of the flame front and another derived from the rate of heat liberated by the material under test are combined to provide a radiant panel index.

³ Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

5. Significance and Use

5.1 This 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. It is intended for use in measurements of the surface flammability of materials exposed to fire. The test is conducted using small specimens that are representative, to the extent possible, of the material or assembly being evaluated. (Example: in terms of their thickness, layering, and any potential substrate.)

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.⁴

5.3 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.

5.4 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 example criteria, concepts and procedures incorporated into Guide E1546 shall be taken into consideration.

6. Apparatus

6.1 The apparatus shall be as shown in Fig. 1 and 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 12 by 18 in. (305 by 457 mm) and shall be capable of operating at temperatures up to 1500°F (815°C). 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 1200 ft³/h (9.4 L/s) air at a pressure of 2.8 in. of water (700 Pa); 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. Observation marks shall be filed on the surface of the specimen holder to correspond with 3-in. (76-mm) interval lines on the specimen.

⁴Robertson, A. F., "Surface Flammability Measurements by the Radiant Panel Method," *Symposium on Fire Test Methods, ASTM STP 344*, ASTM, 1962, pp. 33–46.

Robertson, A. F., Gross, D., and Loftus, J., "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source," *Proceedings, ASTM*, Vol 56, 1956, pp. 1437–1453.

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.

Magee, R. S. and McAlevy III, R. F., "The Mechanism of Flame Spread," *Journal of Fire and Flammability*, Vol 2, 1971, pp. 271–297.

6.1.3 *Framework for Support of the Specimen Holder*—The framework shall have two transverse rods of stainless steel, each 0.50 ± 0.13 in. (12.7 ± 3.3 mm) 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 0.125 in. (3.2 mm) of the values given in Fig. 1.

6.1.4 *Pilot Burner*—The pilot burner shall be a length of stainless steel tubing approximately 8 to 9 in. (203 to 229 mm) long with nominally 0.125 in. (3.2 mm) inside diameter by nominally 0.19 in. (4.8 mm) outside diameter. As an option, to prolong the service life of the pilot burner, the part of the burner that is exposed to radiant energy can be protected with a porcelain tube nominally 0.20 in. (5.2 mm) inside diameter by nominally 0.28 in. (7.14 mm) outside diameter. The burner shall be mounted horizontally and at a slight angle to the intersection of the horizontal plane of the burner with the plane of the specimen. The burner shall also be capable of being moved out of position when not in use. The pilot shall provide a 2 to 3 in. (51 to 76-mm) flame of acetylene gas premixed with air in an aspirating type fitting. The position of the burner tip shall be such that the pilot flame shall contact or shall be within 0.5 in. (12.7 mm) of contacting the upper central surface of the specimen.

6.1.5 *Stack*—The stack shall be made from nominally 0.040 in. (1.0 mm) 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.

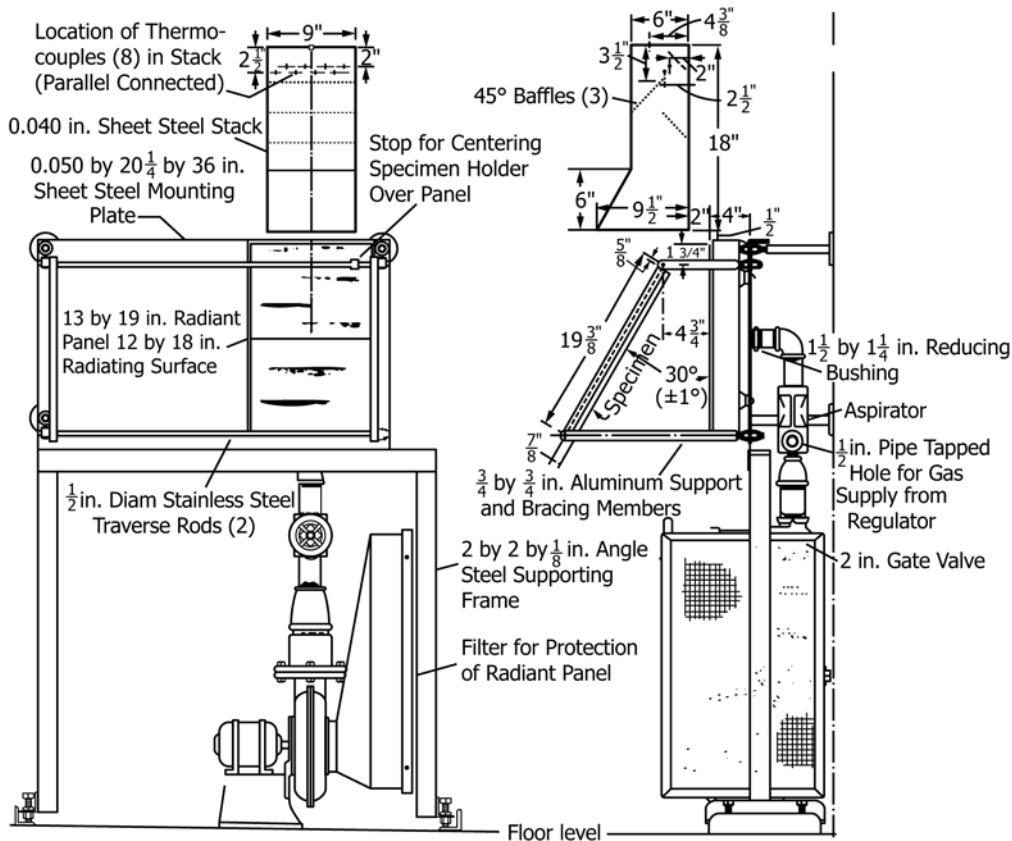
6.1.6 *Thermocouples*—Eight thermocouples of equal resistance and connected in parallel shall be mounted in the stack and supported with porcelain insulators as indicated in Fig. 1 and Fig. 3. The thermocouples shall be Chromel-Alumel Type K, shielded against high heat with insulation resisting up to 2190° F (1200° C), and with wire gauges in the range of 0.014 – 0.020 in. (0.36 – 0.51 mm; 30 AWG–24 AWG) diameter. The mean stack thermocouple temperature rise for unit heat input rate of the calibration burner shall be determined periodically for the specific test apparatus, using the procedure in .

6.1.7 *Data Collection System*—For collecting test data, use one of the following:

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

6.1.7.2 *Computer Data Collection System*—The data acquisition system shall have the capability 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.

6.1.7.3 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 12.5).



Metric Equivalents

in.	mm	in.	mm
0.040	1.0	6	152
1/2	13	9 1/2	241
5/8	16	18	457
7/8	22	19 3/8	492
1 3/4	44	3/4 by 3/4	19 by 19
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	1.3 by 514 by 914
4 3/4	121		

100 ft³/min = 47.21 L/s

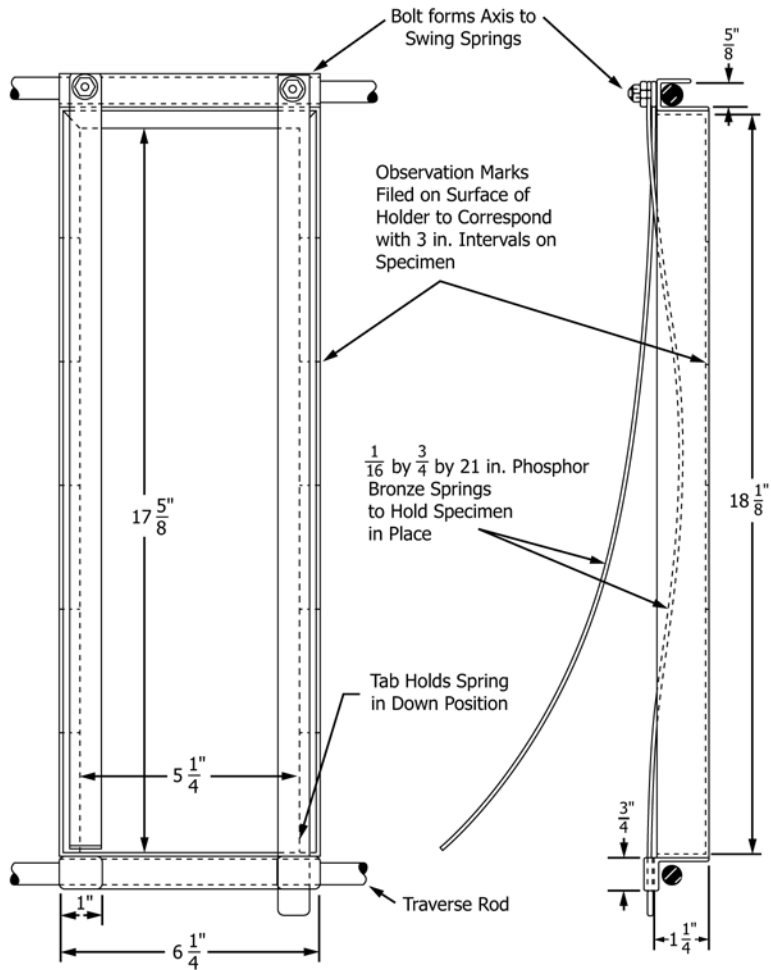
FIG. 1 Details of Construction of Test Equipment

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 needs to produce a velocity of 80 to 100 ft/min (24.4 to 30.5 m/min). Measurements are to be made either with a hot wire anemometer after at least 30 s of insertion of the probe into the center of the stack at a distance of 6 in. (152 mm) 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. The velocity through the stack is not critical for flame-spread measurements provided a stack thermocouple temperature 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 10 in. (254 mm) and 7.5 in. (191 mm) respectively.

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.

NOTE 2—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 250 ft/min.



Metric Equivalents

in.	mm	in.	mm
$\frac{3}{4}$	19	$6\frac{1}{4}$	159
1	25	$17\frac{5}{8}$	448
$1\frac{1}{4}$	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. 2 Specimen Holder

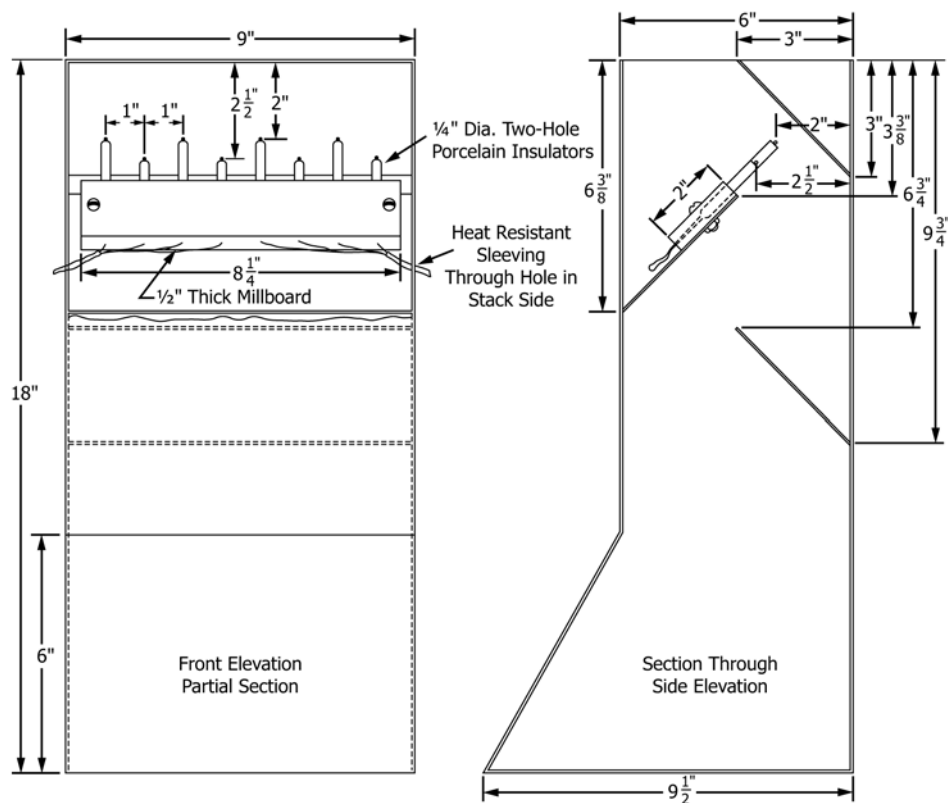
6.1.9 *Radiation Pyrometer*—The radiation pyrometer for standardizing the thermal output of the panel shall be suitable for viewing a circular area 10 in. (254 mm) in diameter at a range of about 4 ft (1.2 m). It shall be calibrated over the operating black body temperature range in accordance with the procedure described in Annex A1.

6.1.9.1 Monitor and record the millivolt output of the radiation pyrometer with the data collection systems described in 6.1.7.

6.1.10 *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.



Metric Equivalents

in.	mm	in.	mm	in.	mm
1/4	6.4	3	76	9	229
1/2	13	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. 3 Thermocouple Mounting Arrangement

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, and 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 specimen shall be 6 by 18 in. (152 by 457 mm) by the sheet thickness, where this is less than 1 in. (25.4 mm). Materials supplied at a thickness greater than 1 in. (25.4 mm) shall be cut to 1 in. (25.4 mm) for testing. At the request of the sponsor, it is possible to test materials greater than 1 in. (25.4 mm) thickness by using an oversized specimen holder.

8.2 Materials intended to be applied to a substrate shall be tested on that substrate.

8.3 For comparison tests, or where the intended application of a finish material is not specified, the finish material shall be prepared for test in accordance with 8.4 – 8.6.

8.4 Opaque sheet materials up to 1/16-in. (1.6-mm) thickness, and liquid films such as paints, etc. intended for application to combustible base materials, shall be applied to 1/4-in. (6.4-mm) thick tempered hardboard using recommended application procedures. The hardboard shall have a mean flame-spread index of 130 to 160 based upon a minimum of four tests performed in accordance with this method.

8.5 Liquid films and other materials for application to a noncombustible base shall be applied to the smooth surface of 1/4-in. (6.4-mm) thick fiber cement board, using specified spreading rate requirements, or, in the absence of requirements, a minimum-coating thickness of 0.030 in. (0.76 mm). Whenever fiber cement board is specified, the material shall be as described in Annex A2.

8.6 A backing of aluminum foil 0.002 in. (0.05 mm) thick, with the bright side against the specimen shall be used.

8.7 Materials, including fabrics, not applied to a base but supported at one or more edges shall be mounted on a special backing of ½-in. (13-mm) thick millboard of which the surface opposite the test specimen is covered with a sheet of highly reflective aluminum foil 0.002 in. thick, with the bright side against the specimen. Millboard spacers ½ by ½ in. (12.7 by 12.7 mm) shall be used at the perimeter of the foil-covered face of the backing to separate the test material from the foil. Flexible materials shall be cut to 10 by 22-in. (255 by 560-mm) size, folded around the frame and fastened to the rear surface of the millboard with tension sufficient only to remove slack.

NOTE 3—Wherever millboard is specified, the material shall be cement bound of commercial quality nominal ½-in. (13-mm) thick and density of $60 \pm 5 \text{ lb/ft}^3$ ($960 \pm 80 \text{ kg/m}^3$).

8.7.1 For cellular elastomers and cellular plastics, whether flexible or not, the back and sides of the test specimen shall be wrapped with aluminum foil 0.002 in. (0.05 mm) thick, with the bright side against the specimen. High density inorganic reinforced cement board, 0.25 in. (6.4 mm) in thickness, shall be used as backing. The test specimen shall be retained in the specimen holder by a 6 by 18-in. (152 by 457-mm) sheet of nominally 1-in. (25.4-mm) hexagonal steel wire mesh, 20 AWG, placed against the exposed face of the specimen. Molded skin or treated surfaces shall face the exposure.

8.7.2 For testing of flexible cellular materials see also Test Method **D3675**, which uses a different pilot burner.

8.8 Finish materials, including sheet laminates, tiles, fabrics, and others applied to a base material with adhesive as well as laminated materials not attached to a base shall be tested for possible increased flame spread or associated hazard due to delamination, cracking, peeling, or other separation of the finish material. An increase in flame spread may be caused by flaming on the reverse face of the test material, or by ignition of the adhesive or base material. Determination of the existence of such effects shall be made as follows:

8.8.1 One or more specimens of the sample material shall be tested as received in the manner prescribed herein for the flame spread determination of ordinary materials.

8.8.2 Materials that tend to delaminate or in any way separate from the specimen holder during the above test exposure shall be retested using one or more specimens in which the material is retained in position by a 6 by 18-in. (150 by 460-mm) sheet of 1-in. (25-mm) hexagonal wire mesh placed in the specimen holder and against the exposed face of the specimen.

8.9 If, in this initial test, any material tends to melt, soften, crack, split, or fall from the specimen holder, it shall be retested with a wire support as described in **8.8.2** and the higher of the two results shall be adopted as the flame spread index.

8.10 All specimens except those over ¾ in. (19.0 mm) thick shall be backed with ½-in. (13-mm) millboard of 60 lb/ft^3 (960 kg/m^3) density.

9. Number of Test Specimens

9.1 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 (see **11.12**).

10. Conditioning

10.1 Pre-dry specimens for 24 h at 140°F (60°C) and then condition to equilibrium (constant weight) at an ambient temperature of $73 \pm 5^\circ\text{F}$ ($23 \pm 3^\circ\text{C}$) and a relative humidity of $50 \pm 5\%$.

11. Procedure

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

11.2 During the conduct of the test, control extraneous drafts by closing windows and doors, stop air-circulating devices, and arrange baffles between the apparatus and any remaining sources of drafts.

11.3 At the start of each testing day, ignite the gas-air mixture passing through the radiant panel and allow the unit to heat for 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 10 in. (254 mm) in diameter. Adjust the rate of air supply to between 750 and 800 ft³/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 $1238 \pm 7^\circ\text{F}$ ($670 \pm 4^\circ\text{C}$).

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

11.5 The adequacy of measures to control drafts shall be established by ensuring that stack temperature variations before the specimen is put in place for test (see **11.7**) do not exceed $\pm 9^\circ\text{F}$ (5°C).

11.6 Ignite the pilot and adjust it to give a flame 2 to 3 in. (51 to 76 mm) long. Move the pilot into operating position. The pilot burner shall remain ignited and in position for the duration of the test whether or not there is flaming of the specimen. For materials that tend to shrink or contract upon application of heat, position the pilot burner flame to directly contact the specimen.

11.7 Place the specimen holder containing the specimen into the supporting framework and start the timer simultaneously. A maximum of 5 min shall elapse 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.

11.8 Record the time of arrival of the flame on the surface of the specimen at each of the 3-in. (76-mm) marks on the specimen holder or on the corresponding lines of the specimen.

At the same time, make the observations for “flash” required in 12.4.3. Also, record observations on dripping and any other behavior characteristics of the specimen that appear to be of interest.

11.9 Record the maximum rise of the stack thermocouples.

11.10 *Exposure Time*—The test is completed once the maximum temperature of the stack thermocouples is reached, as defined by an increase of no more than 5°C over the last 5 min, and either: the flame front has progressed to the 15-in. (380-mm) mark or after an exposure time of at least 15 min, whichever occurs first. The maximum temperature shall be recorded as the maximum temperature measured before the test is discontinued.

11.11 If during the test of one or more of the test specimens, any of the following behaviors occur: (1) molten material flows out of the specimen holder, (2) one or more portions of a test specimen is forcefully displaced from the zone of controlled irradiance (explosive spalling), (3) the test specimen swells sufficiently prior to ignition to touch the burner during combustion, or (4) materials exhibit rapid running or dripping of flaming material due to melting and the steep inclination of the specimen during test; these occurrences shall be noted within the test report and no radiant panel index shall be reported for that test.

11.11.1 With respect to 11.11 (Item 4) materials are considered to exhibit “rapid” running or dripping of flaming material when at any time during the test, flaming droplets fall away from the test specimen at a rate of at least ten flaming drops during any 10 s period, or more than 20 % by mass of the specimen falls to the floor.

11.12 When a test on a specimen does not permit the report of a radiant panel index (as described in 11.11), test an additional specimen of the identical preconditioned test specimens in an attempt to yield a total of four valid test results. Do not incorporate data obtained from the tests noted above, yielding inadequate results, in the averaged data but report the occurrence. If any of the behaviors in 11.11 continues to be observed on the additional specimens during the second attempt, the tests are considered invalid.

12. Calculation

12.1 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 follows:

$$I_s = F_s Q \quad (1)$$

where F_s and Q are as defined in 12.2 and 12.3.

The radiant panel index (I_s) reported shall be the value calculated as above for each of the four specimens tested. The average (I_s) of the four specimens shall be rounded to the nearest multiple of five.

12.2 *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, 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:

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

where t_0 is conventionally 0, and $t_3 \dots t_{15}$ 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.

12.2.1 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.

12.2.2 Points that are left below the final segmented curve are designated “skip points.” Points on the curve are “curve points.” There should be no points above the curve. Using the equation for F_s given in 12.2, 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: example in Annex A1.4.)

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

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

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

12.3 Calculate Q as follows:

$$Q = CT/\beta \quad (3)$$

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 Annex 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 Annex 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—When using English units, arbitrary constant $C = 0.1$, T shall be expressed in degrees F, and β shall be expressed in degrees F per Btu/min.

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

12.4 *Flame Fronts*—Sustained flame fronts shall be taken into account for calculation purposes. Flashing shall be taken into account for reporting purposes, but not used for calculation purposes.

12.4.1 *Sustained Flame Fronts*—A sustained flame front is achieved when a flame front advances from the pilot burner position to or beyond the first 3-in. mark, or from any of the 3-in. marks to or beyond the next 3-in. mark at such a rate that at least 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 12.1.

12.4.2 *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 .

12.4.3 *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 to X inches).”

12.4.4 *Rapid Flame Spread*—If flame spreads from the pilot burner position to the first 3-in. mark or from any of the 3-in. marks to the next in 3 s or less, the fact shall be mentioned in the report and the word “Flashing” in parentheses shall follow the radiant panel index; it shall be reported in the form, for example, “Radiant panel index = 100 (Flashing to X inches).”

12.5 For low-density, cellular, or other 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.

13. Report

13.1 Report the following information:

13.1.1 Complete identification of the material tested, including source, manufacturer’s code numbers, previous history, etc.,

13.1.2 Type and form of test specimens (for example, molded, slab, core, skin, surface treated, etc.), dimensions, color, and whether tested with or without backing or aluminum foil,

13.1.3 Conditioning procedure used. A justification shall be given if the procedure does not comply with that specified in 10.1,

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

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

13.1.6 Individual radiant panel indices (I_s) for the specimens tested,

13.1.7 The average radiant panel index (I_s) rounded to the nearest multiple of five,.

13.1.8 Any visual characteristics of the individual specimens, and

13.1.9 Designation of “Flashing” where applicable, including time of occurrence and any other visual burning characteristics.

14. Precision and Bias

14.1 This test method has been in use for many years, but no information has been presented to ASTM International upon which to base statements on precision or bias. Round robin testing is planned to develop data for a precision statement.

15. Keywords

15.1 beta factor; fire-test-response standard; flame spread factor; radiant panel index; heat evolution factor; radiant heat energy; radiant panel; surface flame spread; surface flammability

ANNEXES

(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 $1238 \pm 10^\circ\text{F}$ ($670 \pm 5^\circ\text{C}$). 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 356 to 446°F (180 to 230°C) when no specimen is in position. Place an inorganic reinforced cement board specimen in position, ignite the pilot burner, adjust the flame to a 2 to 3-in. (51 to 76-mm) length, and place the burner into the operating position. Record the increase in

temperature of 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 the measurement of stack thermocouple temperature rise in the testing of materials.

A1.2.2 Place an inorganic reinforced cement board specimen, with a nominally 0.5-in. (13-mm) millboard backing in the test position, 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 12 to 15-in. (305 to 381-mm) length of nominally 0.25-in. (6-mm) standard wrought iron or steel pipe capped at one end and containing ten 0.070 ± 0.008 -in. (1.8 ± 0.2 -mm) diameter radial holes spaced 0.625 ± 0.04 in. (16 ± 1 mm) on centers along a line parallel to the axis of the pipe. Place the center-line of the pipe burner in horizontal position 1 ± 0.1 in. (25 ± 2 mm) (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 11.6. 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 shall 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 60°F (15.6°C) and a standard pressure of 30.0 in. (762 mm) Hg (101 kPa). Plot the maximum stack thermocouple temperature rise in degrees Fahrenheit (or Celsius) as a function of the corresponding measured heat input in Btu per minute (or kilowatts). The value of β used in the formula in 12.3 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 180°F (100°C). For those using degrees Fahrenheit for T in 12.3, β is the ratio of a temperature rise of 180°F to the heat input in Btu per minutes producing it. For those using degrees Celsius for T in 12.3, β is the simple ratio of a temperature rise of 100°C to the heat input in kilowatts producing it.

A1.3 Calibration Check

A1.3.1 The proper calibration of the radiation pyrometer at a blackbody temperature of 1238°F (670°C) as described in 6.1.9 and A1.1.1 is important. Use an outside calibration agency to provide calibration traceable to the National Institute of Standards and Technology (NIST).

A1.4 Example of Flame Spread Factor, F_s , Calculation (12.2.1 and 12.2.2)

A1.4.1 Suppose $t_3 = 3$ min, $t_6 = 5$ min, $t_9 = 6$ min, $t_{12} = 10$ min, and $t_{15} = 12$ min. These points appear in a graph in Fig. A1.1. t_3 , t_6 , and t_{12} are recognized as skip points with the first two being consecutive. Thus using the equation in 12.2 modified by 12.2.2:

$$\frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} \text{ are replaced by } \frac{9}{t_9 - t_0} \quad (\text{A1.1})$$

and

$$\frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}} \text{ are replaced by } \frac{4}{t_{15} - t_9} \quad (\text{A1.2})$$

The final equation becomes:

$$F_s = 1 + \frac{9}{t_9 - t_0} + \frac{4}{t_{15} - t_9} \quad (\text{A1.3})$$

Thus, substituting the appropriate times:

$$F_s = 1 + (9/6) + (4/6) = 3.17 \quad (\text{A1.4})$$

A1.5 Surface Flammability Standard Material

A1.5.1 The National Bureau of Standards (now National Institute of Standards and Technology (NIST), Gaithersburg, MD 20899) has made available a surface flammability standard material, for checking operational and procedural details of this test method, through its Standard Reference Materials Program. The use of this standard material does not replace the need for following the calibration and standardization procedures outlined herein.

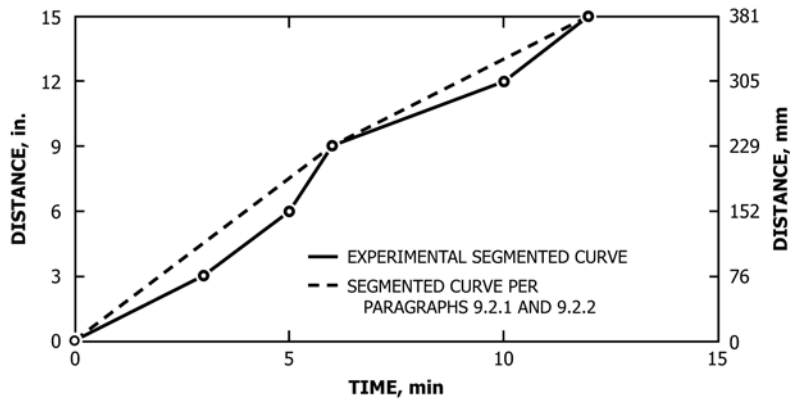


FIG. A1.1 Example of Flame Spread Factor

A2. FIBER-CEMENT BOARD REQUIREMENTS

A2.1 Introduction:

A2.1.1 The fiber-cement board shall comply with Specifications C1288 or C1186, Grade II, and the following additional properties:

A2.1.1.1 Nominal thickness shall be 1/4 in. (6.3 mm).

A2.1.1.2 Density = 90 ± 10 lb/ft³ (1444 ± 160 kg/m³).

A2.1.1.3 Board shall be uncoated.

A2.1.1.4 The board shall stay in-place during an E162 test.

A2.1.1.5 Shall be suitable for test sample adhesion.

APPENDIXES

X1. COMMENTARY

X1.1 There are several different test methods for assessing the surface flammability of materials. This test method 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). The references in footnote 5 describe the original test method, as developed at the National Bureau of Standards, and

contain test data for this method and for other test methods on several building materials. The indices determined in Test Method E84 and in Test Method E162 are different and should not be compared directly.

X1.2 Aluminum foil is used against the specimen to prevent melting and destroying the back board/holders.

X2. HISTORICAL PHOTOGRAPH

X2.1 Fig. X2.1 is a photograph of typical radiant panel flame test equipment, circa mid-1970s, and is shown for historic reference only. The appearance of the apparatus

currently manufactured will, in most cases, differ from the photograph.



FIG. X2.1 Historic Photograph of Radiant Panel Flame Test Equipment

X3. CONSIDERATIONS

X3.1 With respect to 6.1.4 regarding the pilot burner, the following settings have been found to achieve the required 2 to

3 in. high flame; acetylene pressure regulated to approximately 10 psi and the air pressure regulated to approximately 20 psi.

X4. RATIONALE FOR CONCERNS REGARDING FLAMING DROPLETS

X4.1 Sections 11.11 and 11.11.1 explain that, if during the conduction of a test, materials exhibit rapid running or dripping of flaming material due to melting, the test is to be deemed invalid. This section further discusses the rationale for this requirement.

X4.2 Materials that melt rapidly during the test cannot adequately be assessed with Test Method E162 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.

X4.3 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^{5,6} 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 11.11 and 11.12). When tests are invalid no radiant panel index value can be assigned to the material.

X4.4 The fire hazard associated with materials that undergo rapid melting, and thus cannot be tested appropriately using Test Method E162, but generate no flaming droplets or flaming materials, may be different from that of materials that both melt and generate flaming droplets.

⁵ Bundy, M., and Ohlemiller, T. J., Bench-Scale Flammability Measures for Electronic Equipment, *NISTIR-7031*, NIST, Gaithersburg, MD, 2003.

⁶ Bundy, M. and Ohlemiller, T. J., Full-Scale Flammability Measures for Electronic Equipment, *NIST Technical Note 1461*, NIST, Gaithersburg, MD, 2004.

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