Designation: E 162 – 98

An American National Standard

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

This standard is issued under the fixed designation E 162; 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 Department of Defense.

1. Scope

1.1 This fire-test-response standard, to be used for research and development purposes, covers the measurement of surface flammability of materials. It is not intended for use as a basis of ratings for building code purposes.

1.2 *This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire-hazard or fire-risk of materials, products, or assemblies under actual fire conditions. However, results of the test may be used as elements of a firehazard 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.*

1.3 *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.*

1.4 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

E 176 Terminology Relating to Fire Standards[2]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to the terminology contained in Terminology E 176.

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. (300 by 460-mm) panel in front of which an inclined 6 by 18-in. (150 by 460 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 relating to the rate of heat liberation by the material under test are combined to provide a flame spread index.

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 measurements on materials whose surfaces may be exposed to fire. The test is made on specimens of small size (6 by 18 in. (150 by 460 mm)) that are representative, to the extent possible, of the material or assembly being evaluated. The test is intended for research and development only.

5.2 The rate at which flames will travel along surfaces depends upon the physical and thermal properties of the material, its method of mounting and orientation, the type and level of fire or heat exposure, the availability of air, and properties of the surrounding enclosure.[3]

6. Apparatus

6.1 The apparatus shall be essentially as shown in Figs. 1 and 2 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 12 by 18 in. (300 by 460 mm) and shall be capable of operating at temperatures up to 1500°F (815°C). 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 100 ft^3/min (50 L/s) air at

[1] This test method is under the jurisdiction of ASTM Committee E-5 on Fire Standards and is the direct responsibility of Subcommittee E05.22 on Surface Burning.

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[2] *Annual Book of ASTM Standards*, Vol 04.07.

[3] Robertson, 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.

FIG. 1 Radiant Panel Flame Spread Test Equipment

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. 3 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.

6.1.3 *Framework for Support of the Specimen Holder*—The framework shall have two transverse rods of stainless steel, each ½ in. (13-mm) in diameter, with a stop to center the specimen holder directly in front of the radiant panel. The support and bracing members should 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 ⅛ in. (3.2 mm) of the values given in Fig. 2.

6.1.4 *Pilot Burner*—The pilot burner shall be a length of stainless steel tubing aproximately 8 to 9 in. (203 to 229 mm) long with ⅛-in (3.2-mm) inside diameter by 3⁄16-in. (4.8 mm) outside diameter. The part of the burner that is exposed to radiant energy may be protected with a porcelain tube 13⁄64-in. (5.16 mm) inside diameter by 9⁄32-in. (6.84 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 gas premixed with air in an aspirating type fitting. Acetylene has been found satisfactory for this purpose. The position of the burner tip is such that the flame will contact or be within ½ in. (12.7 mm) of contacting the top center area of the specimen.

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

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. 2 and Fig. 4. Each junction shall be formed by fusing the end of a twisted pair of Chromel and Alumel wires of 0.020-in. (0.5-mm) diameter.

6.1.7 *Automatic Potentiometer Recorder*—An automatic potentiometer 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. The recorder should give a continuous record or shall print at time intervals of not more than 15 s.

6.1.8 *Hood*—A hood with exhaust blower placed over the stack is required. The blower should produce a velocity of 100 ft/min (0.5 m/s) (30.5 m)/min at the top of the stack with the radiant panel not operating, or approximately 250 ft/min (1.3 m/s) with the radiant panel at operating temperature. The velocity through the stack is not critical for flame-spread measurements provided a stack thermocouple temperature calibration is performed (see Annex A1.2) for the established test conditions. The hood surfaces should clear the top and sides of the stack by a minimum of 10 in. (254 mm) and 7½ in. (191 mm) respectively.

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 the Annex A1.

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.

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

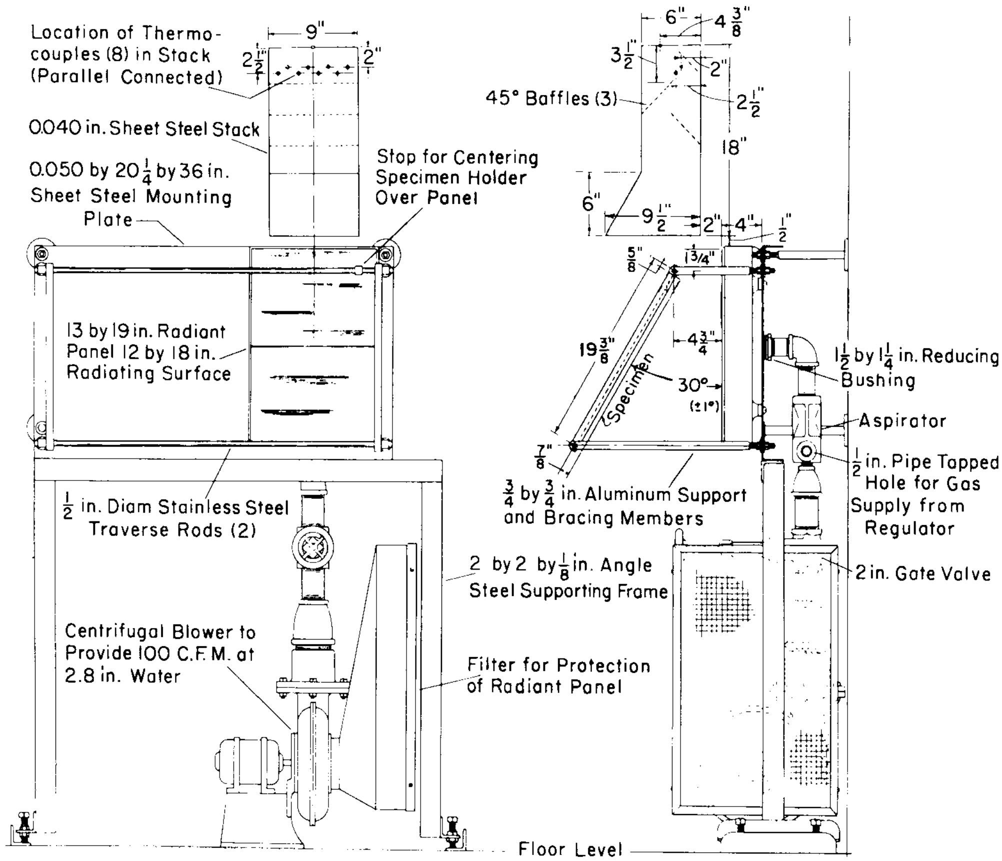
7. Test Specimens

7.1 The test specimen shall be 6 by 18 in. (150 by 460 mm) by the sheet thickness, where this is less than 1 in. (25 mm). Materials supplied in greater thickness shall be cut to 1 in. (25 mm). At the request of the sponsor, materials may be tested in thickness greater than 1 in. (25 mm), but an oversize specimen holder will then be needed.

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

7.3 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 7.4-7.7.

7.4 Sheet materials that are opaque to infrared radiation and greater than 1⁄16-in. (1.6-mm) thickness are not applied to a base.



Metric Equivalents

in.	mm	in.	mm
0.040	1.0	6	152
½	12.7	9½	241
⅝	16.0	18	457
⅞	22.2	19⅜	492
1¾	44	¾by ¾	19.2 by 19.2
2	51	1½ by 1¼	38 by 32
2½	64	12 by 18	305 by 457
2.8	71	13 by 19	330 by 483
4	102	2 by 2 by ⅛	51 by 51 by 3.2
4⅜	111	0.050 by 20¼ by 36	13 by 514 by 914
4¾	121		

100 ft^3/min = 47.21 L/s

FIG. 2 Details of Construction of Test Equipment

7.5 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 ¼-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.

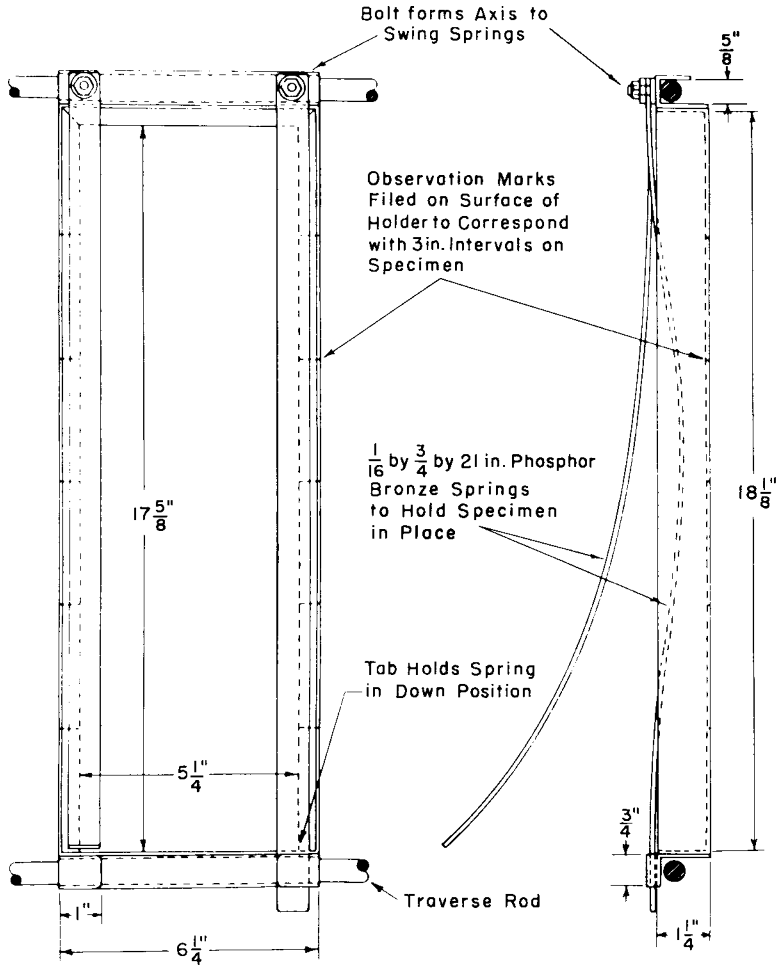
7.6 Liquid films and other materials for application to a noncombustible base shall be applied to the smooth surface of ¼-in. (6.4-mm) thick inorganic reinforced cement board, using specified spreading rate requirements, or, in the absence of requirements, a minimum-coating thickness of 0.030 in. (0.76 mm).

NOTE 1—Wherever inorganic reinforced cement board[4] is specified, the material shall be nominal ¼in. (6.3 mm) thick, high density (110± 5 lb/ft^3 (1762 ± 80 kg/m^3)) and uncoated.

7.7 If a backing of aluminum foil 0.002 in. (0.05 mm) thick, with the bright side against the specimen, produces a higher flame spread index than without the foil, this higher result shall be adopted as the flame spread index.

7.8 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

[4] Manville Flexboard II, available through local Manville distributors, has been found satisfactory for this purpose.



Metric Equivalents

in.	mm	in.	mm
¾	19.0	6¼	159
1	25	17⅝	433
1¼	32	18⅛	460
3	76	1⁄16 by ¾by 21	1.6 by 19 by 533
5¼	133		

FIG. 3 Specimen Holder

reflective aluminum foil 0.002 in. thick, with the bright side against the specimen. Millboard spacers ½by 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.

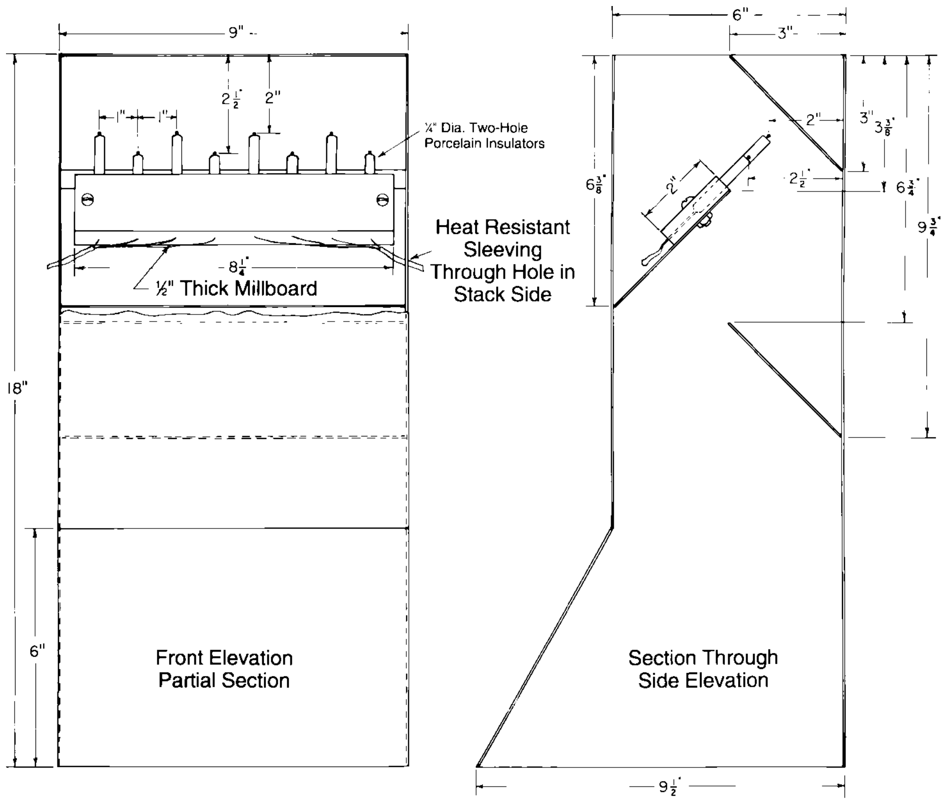
NOTE 2—Wherever millboard is specified, the material shall be cement bound of commercial quality nominal ½-in. (13-mm) thick and density of 60 ± 5 lb/ft^3 (960 ± 80 kg/m^3).[5]

7.8.1 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. Inorganic reinforced cement board shall be used as backing. The test specimen shall be retained in the specimen holder by a 6 by 18-in. (150 by 460-mm) sheet of 1-in. (25-mm) hexagonal steel wire mesh, 20 to 22 AWG, placed against the exposed face of the specimen. Molded skin or treated surfaces shall face the exposure.

7.9 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:

7.9.1 One or more specimens of the sample material shall be tested as received in the manner prescribed herein for the flame

[5] NAMPRO 901 millboard, available from Quin-T Corp., 140 East 16th Street, Erie, PA 16501, or equivalent has been found satisfactory for this purpose.



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. 4 Thermocouple Mounting Arrangement

spread determination of ordinary materials.

7.9.2 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.

7.9.3 Materials as described in this paragraph, and tested in accordance with 7.9.1 or 7.9.1 and 7.9.2 combined shall be further tested using one or more specimens. These specimens shall be prepared by scoring grooves of 1/16-in. (1.6-mm) max width in the finish material, making one longitudinal groove 1 in. (25 mm) from an edge, and five lateral grooves 4 in. (102 mm) apart and 1 in. (25 mm) from the top and bottom edges. The resulting pattern contains four large sections, each 4 by 5 in. (102 by 127 mm) held on the back by the substrate lamina or by adhesive, and supported on the unscored side by the specimen holder. Unapplied laminates should be grooved through three fourths of the thickness; materials applied to a base should be scored completely through the finish.

7.9.4 The flammability test of the sample material shall be conducted under the appropriate condition of 7.9.1-7.9.3 that had yielded the highest flame spread index. However, if in a grooved assembly any increase in the flame-spread index can be attributed primarily to accelerated flame travel within the grooves, the flammability test shall be conducted in the conventional manner, without grooves.

7.10 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 7.9.2 and the higher of the two results shall be adopted as the flame spread index.

7.11 All specimens except those over 3/4 in. (19.0 mm) thick shall be backed with 1/2-in. (13-mm) millboard of 60 lb/ft ^{3} (960 kg/m^3) density. To protect the back surface of the specimen, a 1 by 6-in. (25 by 152-mm) strip of flexible ceramic paper shall be placed across the top edge of the specimen and folded down over the back face of the millboard.

NOTE 3—Wherever ceramic paper is specified, the material shall be capable of maintaining its integrity with a minimum service temperature of 2300°F (1260°C).[6]

[6] Type 300 Ceramic Paper, in appropriate thicknesses, available from Cotronics Corporation, 3379 Shore Parkway, Brooklyn, NY 11235, or equivalent has been found satisfactory for this purpose.

8. Conditioning

8.1 Predry specimens for 24 h at 140°F (60°C) and then condition to equilibrium at an ambient temperature of 73 ± 5°F (23 ± 3°C) and a relative humidity of 50 ± 5 %.

9. Number of Test Specimens

9.1 At least four specimens of each sample shall be tested under the conditions applicable to the type of sample.

10. Procedure

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

10.2 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.

10.3 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 placed 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 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 1238 ± 7°F (670 ± 4°C).

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

10.5 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 10.7) do not exceed ±9°F (5°C).

10.6 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.

10.7 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.

10.8 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 11.4.1. Also, record observations on dripping (see 11.5) and any other behavior characteristics of the specimen that appear to be of interest.

10.9 Record the maximum rise of the stack thermocouples.

10.10 *Exposure Time*—The test is completed when the flame front has progressed to the 15-in. (380-mm) mark or after an exposure time of 15 min, whichever occurs first, provided the maximum temperature of the stack thermocouples is reached.

11. Calculation

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

$$I_s = F_s Q$$

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 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:

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

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 may 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." There should be no points above the curve. 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: example in Annex A1.5.)

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.

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

11.3 Calculate Q as follows:

$$Q = CT/\beta$$

where:

C = arbitrary constant 7.7, 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.)

11.4 *Flame Fronts Not Sustained*, All flame fronts, however temporary, are to be taken into account.

11.4.1 *Rapid Flame Spread*—If flame spreads from any of the 3-in. marks to the next in 3 s or less, the fact should be mentioned in the report and the word "Flashing" in parentheses should follow the flame spread index; it should be reported in the form: for example, "Flame spread index = 100 (Flashing)."

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 should be reported in addition to the regularly determined flame spread index.

11.6 For low-density, cellular, or other materials in which the flaming is rapid and is limited to the early part of the test exposure, a slight temperature rise may remain undetected if recording is done intermittently (for example, at 15-s intervals). Continuous recording of the stack thermocouple temperature is required in such cases.

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, for example, molded, slab, core, skin, surface treated, etc.; dimensions, and whether tested with or without backing or aluminum foil,

12.1.3 Conditioning procedure used if different from that specified in 8.1,

12.1.4 Number of specimens tested,

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

12.1.6 Average flame spread index for each set of specimens and range, and,

12.1.7 Any visual characteristics of the individual specimens.

13. Precision and Bias

13.1 A precision and bias statement is being developed.

14. Keywords

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

ANNEX

(Mandatory Information)

A1. PROCEDURE FOR CALIBRATION OF APPARATUS

A1.1 Radiation Pyrometer [7]

A1.1.1 Calibrate the radiation pyrometer by means of a conventional blackbody enclosure placed within a furnace and maintained at a uniform temperature of 1238°F (670°C). The blackbody enclosure may consist of a closed Chromel metal cylinder with a small sight hole in one end. Sight the radiation pyrometer upon the opposite end of the cylinder where a thermocouple indicates the blackbody temperature. Place 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 stack velocity, note the temperature of the stack thermocouples. It is recommended that initial positioning of the exhaust hood system 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 continuously the increase in temperature of the stack thermocouple and use this 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 ½-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 ¼-in. standard wrought iron or steel pipe capped at one end and containing ten 0.070-in. (1.8-mm) diameter radial

[7] 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, describes in detail a method for testing the surface flammability of building materials developed at the National Institute of Standards and Technology and contains data comparative with other test methods.

holes spaced ⅝ in. (16 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 in. (25 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 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 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. 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 flame spread index 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 180°F (100°C). For those using degrees Fahrenheit for T in 11.3, β is 57 times the ratio of a temperature rise of 180°F to the heat input in Btu per minutes producing it. 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.

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. 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 the Center for Fire Research, National Institute of Standards and Technology, Washington, DC 20234.

A1.4 Example of Flame Spread Factor, *F*, Calculation (11.2.1 and 11.2.2)

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 11.2 modified by 11.2.2:

$$\frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} \text{ are replaced by } \frac{9}{t_9 - t_0}$$

and

$$\frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}} \text{ are replaced by } \frac{4}{t_{15} - t_9}$$

The final equation becomes:

$$F_s = 1 + \frac{9}{t_9 - t_0} + \frac{4}{t_{15} - t_9}$$

Thus, substituting the appropriate times:

$$F_s = 1 + (9/6) + (4/6) = 3.17$$

A1.5 Surface Flammability Standard

A1.5.1 For checking operational and procedural details of this standard, a surface flammability standard is available, at nominal cost, through the Standard Sample Office, National Institute of Standards and Technology, Washington, DC 20234. The use of this standard material does not obviate the need for following the calibration and standardization procedures outlined herein.

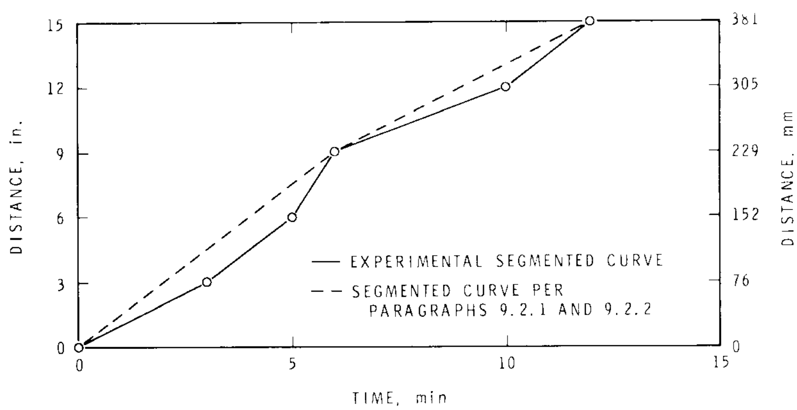


FIG. A1.1 Example of Flame Spread Factor