



Designation: D 3675 – 01

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 describes the measurement of surface flammability of flexible cellular materials.
- 1.3 *This standard measures and describes the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not, by itself, incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*
- 1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*
- 1.5 Fire testing 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:*
 - E 84 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

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

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

2.2 *ISO Standards:*³

ISO 13943 Fire Safety— Vocabulary

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to the terminology contained in Terminology E 176 and ISO 13943. In case of conflict, the definitions given in Terminology E 176 shall prevail.

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

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *radiant panel index, I_s, n* —the product of the flame spread factor, F_s and the heat evolution factor, Q .

4. Summary of Test Method

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

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

5. Significance and Use

5.1 This test method is intended for use when measuring surface flammability of flexible cellular materials exposed to fire. The test method provides a laboratory test procedure for measuring and comparing the surface flammability of materials when exposed to a prescribed level of radiant heat energy. The test is conducted using specimens that are representative, to the extent possible, of the material or assembly being evaluated.

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

For example, if an assembly is required to be tested, such specimens shall replicate the type and thickness of all the layers present in the assembly being evaluated.

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

5.3 Test Method 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 conditions. If different test conditions are substituted or the end-use conditions are changed, it is not always possible by or from this test to predict changes in the fire-test-response characteristics measured. Therefore, the results are valid only for the fire test exposure conditions described in this procedure.

5.5 If the test results obtained by this test method are to be considered as part of an overall assessment of fire hazard in a building or structure, then the criteria, concepts and procedures incorporated into Guide E 1546 shall be taken into consideration.



FIG. 1 Radiant Panel Flame Spread Test Equipment

6. Apparatus

6.1 The apparatus shall be essentially as shown in Fig. 1 and Fig. 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 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.

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, or other suitable non-combustible material which will not be affected by the heat input during the test. Observation marks shall be filed on the surface of the specimen holder to correspond with 75-mm (3-in.) interval lines on the specimen.

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

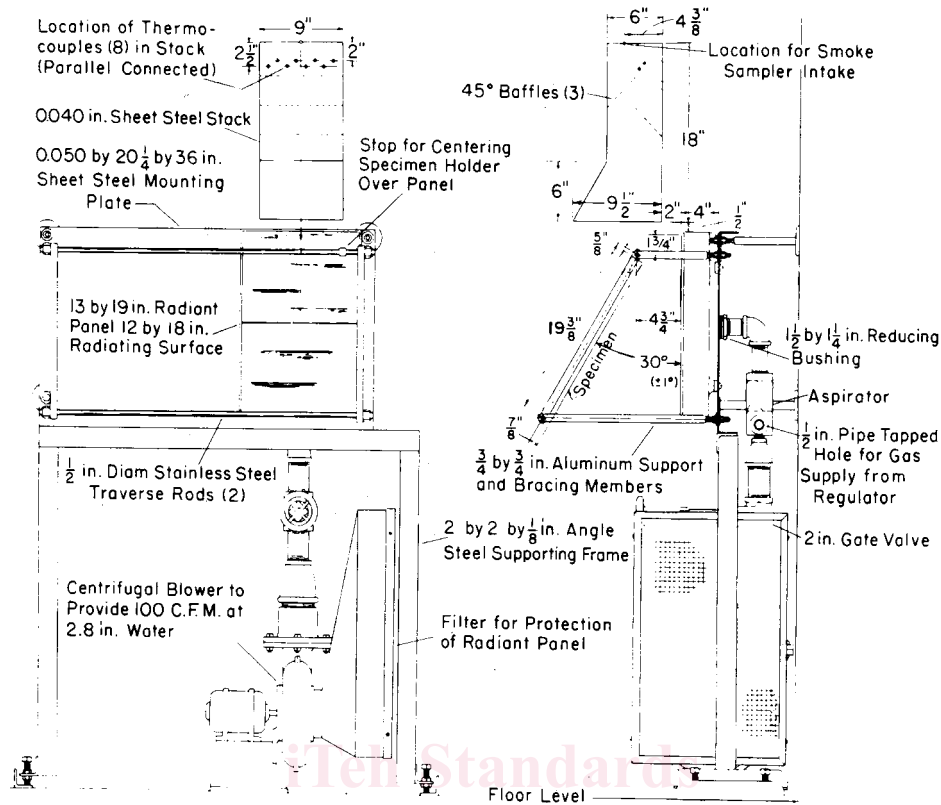
6.1.3 *Framework for Support of the Specimen Holder*—The framework shall have two transverse rods of stainless steel, each 12.5 mm ± 3.0 mm (0.5 ± 0.13 in.) in diameter, with a stop to center the specimen holder directly in front of the radiant panel. The support and bracing members shall be constructed from metal stock. Since the angle of the specimen and its position with respect to the panel are critical, the framework dimensions specifying these conditions shall be within 3.0 mm (0.13 in.) of the values given in Fig. 2.

6.1.4 *Pilot Burner*—The pilot burner shall be a porcelain tube 203–230 mm (8–9 in.) in length, nominally 6.3 mm (0.25 in.) in diameter, with two holes 1.5 ± 0.1 mm (0.059 ± 0.004 in.) in diameter equally spaced in the tube (see Fig. 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 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. Properly adjusted, the pilot flame shall have 25-mm (1-in.) inner blue cones and should impinge on the upper central surface of the specimen within 13 mm (0.5 in.) of the edge of the specimen support frame. Flow rates of 0.015 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.

6.1.5 *Stack*—The stack shall be made from nominally 1.0-mm (0.040-in.) sheet steel with shape and dimensions as shown in Fig. 2. The position of the stack with respect to the

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

⁵ Also see Test Method E 162.



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

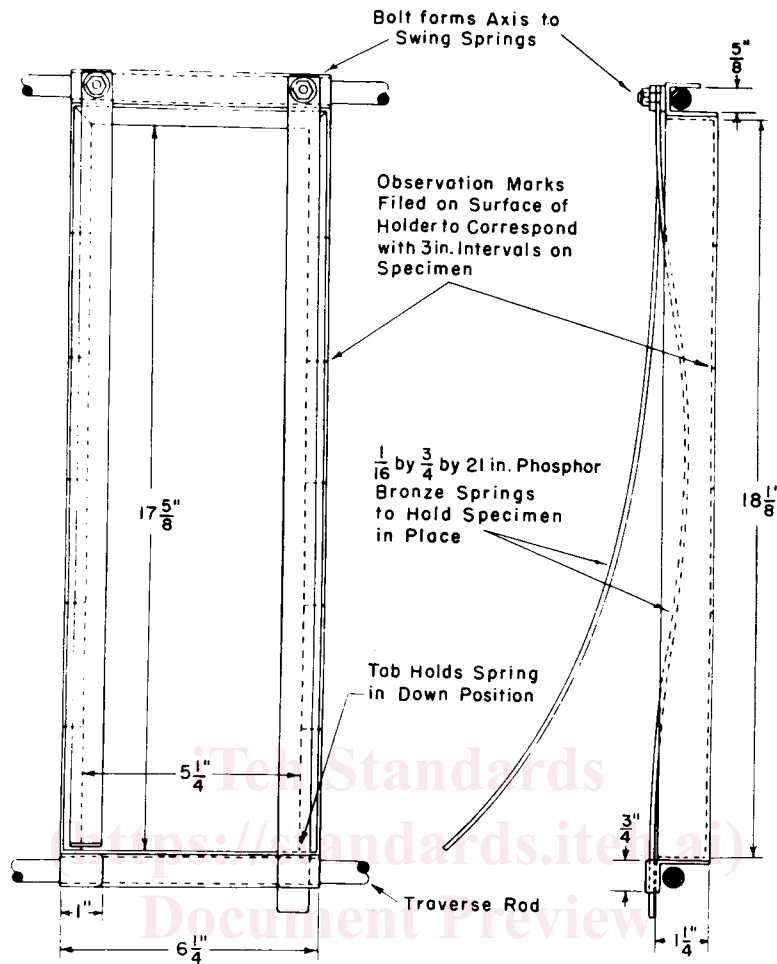
specimen and radiant heat panel shall also comply with the requirements of Fig. 2.

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. 5. The thermocouples shall be Chromel-Alumel Type K, shielded against high heat with insulation resisting up to 1200°C (2170°F), and with wire gages in the range of 0.36–0.51 mm (0.14–0.20 in.; 30 AWG–24 AWG) diameter. The mean stack thermocouple temperature rise for unit heat input rate of the calibration burner, β , shall be determined periodically for the specific test apparatus, using the procedure in A1.2.

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

a computerized data acquisition system shall be permitted to be used. The data acquisition system shall have facilities to record the temperature output from the thermopile. The data acquisition system shall have an accuracy of 0.01% of the maximum temperature to be measured. Whichever system is used, it shall be capable of recording, or printing, data at least every 5 s for a minimum of 1 h. For cases where preliminary tests indicate rapid flame spread, a system shall be used capable of acquiring data fast enough to ensure adequate results (see 11.6).

6.1.8 *Hood*—A hood with exhaust blower placed over the stack is required. The blower shall produce a velocity that adequately exhausts all of the smoke and combustion gases. The blower shall be capable of producing a velocity of 0.5m/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



Metric Equivalents

in.	mm	in.	mm
$\frac{3}{4}$	19.0	$6\frac{1}{4}$	159
1	25	$17\frac{7}{8}$	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

thermocouple calibration is performed (see 6.1.6 and A1.2) for the established test conditions. The hood surfaces shall clear the top and sides of the stack by a minimum of 250 mm (10 in.) and 190 mm (7.5 in.) respectively.

6.1.9 *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.

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

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

7. Hazards

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

7.2 The exhaust system must be so designed and operated that the laboratory environment is protected from smoke and gas. The operator shall be instructed on ways to minimize exposure to combustion products by following sound safety and industrial hygiene practices. For example, ensure that the exhaust system is working properly and wear appropriate

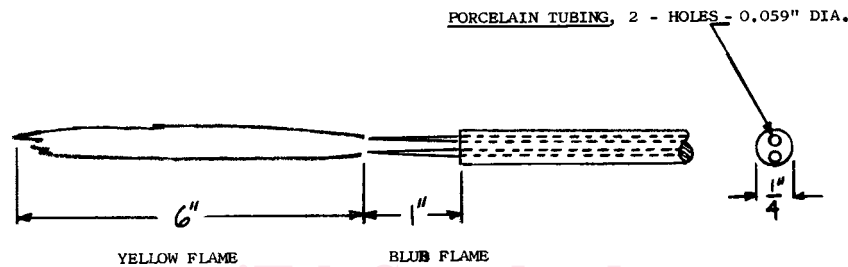
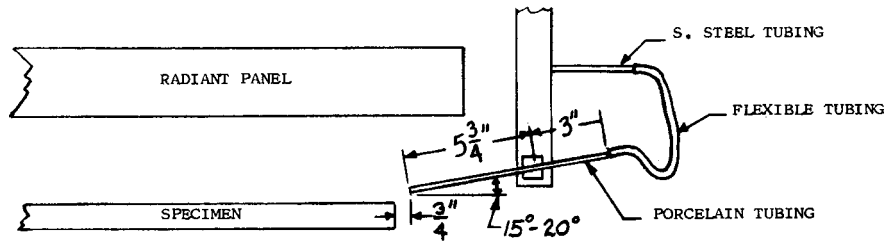


FIG. 4 Pilot Burner

clothing including gloves, safety glasses, breathing apparatus (when hazardous fumes are expected).

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

8. Test Specimens

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

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

8.3 The back and sides of the test specimen shall be wrapped with aluminum foil, the shiny side against the test specimen, 0.05 mm (0.002 in.) in thickness. High density inorganic reinforced cement 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.

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

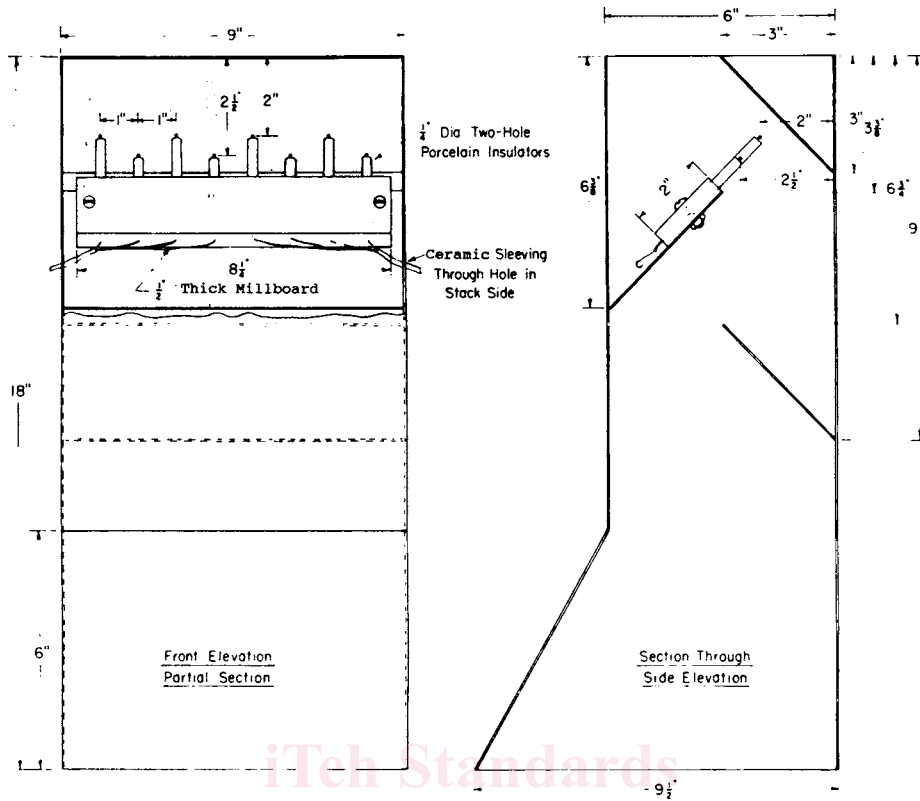
10.1 Remove combustion product deposits from the thermocouples by brush cleaning or other effective method after each test.

10.2 At the start of each day, ignite the gas-air mixture passing through the radiant panel and allow the unit to heat for at least 0.5 h. Before each test, check the radiant output by means of the radiation pyrometer. Do this by placing the pyrometer in such a manner as to view a central panel area about 250 mm (10 in.) in diameter. Adjust the rate of 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).

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

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

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



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

<https://standards.iteh.ai/catalog/standards/sis/maba41-2251-41d1-842d-b8923d002ccc/astm-d3675-01>

from the conditioning chamber until it is placed in position on the framework. During this time, place the specimen and holder in an appropriate vapor barrier jacket, removing it only when the specimen and holder are placed on the framework for the test. A polyethylene bag has been found suitable as a vapor barrier envelope.

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

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

10.8 *Exposure Time*—The test is completed when the flame front has progressed to the 375 mm (15 in.) mark on the specimen or after an exposure time of 15 min, whichever occurs earlier, provided the maximum temperature of the stack thermocouples is reached.

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

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

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

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

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

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