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Standard Test Method for SURFACE FLAMMABILITY OF BUILDING MATERIALS USING AN 8-ft (2.44-m) TUNNEL FURNACE[1]

This standard is issued under the fixed designation E 286; 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 test method provides comparative measurement of surface flame spread of building materials when exposed to thermal radiation and natural draft conditions. The materials or assemblies of materials must be capable of being mounted and supported within the 14-in. (356-mm) by 8-ft (2.44-m) frame of the furnace during the test.

1.2 This test method also includes a photoelectric measurement of the light attenuation produced by the smoke in the vertical furnace stack during the burning of the test specimen.

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *This standard should be used to measure and describe the properties of materials, products or assemblies in response to heat and flame under controlled laboratory 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 this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

1.5 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standard:*

E 84 Test Method for Surface Burning Characteristics of Building Materials[2]

2.2 *ASTM Adjunct:*

Tunnel Furnace and Combustion Furnace (E 286)[3]

2.3 *South Africa Standard:*

SABS Method 963 Surface Fire Index of Materials Used in Buildings[4]

3. Significance and Use

3.1 This flammability test is intended for use in product development and manufacturing control of building materials, and is not primarily intended as a basis for regulatory purposes where surface flamespread is of prime importance.

3.2 This test method provides relative values of flame spread index in the range from 0 to 200. The flame spread index determined from this test method is different from that determined by Test Method E 84. Due to the limited heating rate of the furnace, the actual flame spread for materials having a flame spread in excess of 200 may not be reflected in the test results.

3.3 The thermal exposure to the test specimen is applied primarily by radiant flux from a heated metal plate, plus a small ignition gas flame at the lower end of the specimen. Therefore, this often results in fire-retardant treated products being exposed throughout the test in a non-flaming mode, with a resultant high smoke density. How-

[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] Five detailed drawings of the apparatus are available at a nominal cost from ASTM Headquarters. Order PCN 12-502860-00.

[4] Available from South Africa Bureau of Standards, Private Bag X191, Pretoria, Republic of South Africa.

ever, these high smoke density values are useful in comparing one retardant versus another.

3.4 In this procedure, the specimens are subjected to one or more specific sets of laboratory fire test exposure conditions. If different test conditions are substituted or the anticipated end-use conditions are changed, it may not be possible by or from this test to predict changes in the performance characteristics measured. Therefore, the results are strictly valid only for the fire test exposure conditions described in this procedure.

4. Apparatus

4.1 The apparatus shall consist essentially of a gas-heated furnace approximately 10.5 ft (3.2 m) long with a separate combusion chamber to accommodate a test specimen 13.75 in. (349 mm) wide by 8 ft (2.44 m) long. General views of the exterior of the tunnel furnace and of the specimen combustion chamber are given in Figs. 1 and Fig. 2.[3]

4.2 The furnace shall slope at a 6° angle from end to end and have three compartments: the firebox ((*2*) in Fig. 1) extending the entire length of the furnace; the specimen combustion chamber (above the partition plate, (*5*) in Fig. 2); and the hood and stack ((*6* and *8*) in Fig. 1).

4.3 A 12-gage, Type 310, stainless steel partition (Fig. 2) shall be located between the firebox and the combustion chamber. Thirty-three holes, 1.59375 in. (40.5 mm) and 2.5625 in. (65.0 mm) on center, shall be centered on a line 1.3125 in. (33 mm) from the edge of the partition on the low side of the combustion chamber. (The first hole shall be 5 in. (127 mm) from the front edge of the combustion chamber.) Meker burner tops 1.75 in. (44.4 mm) in diameter with 1.4375-in. (36.5-mm) openings shall be inserted into each of these holes. Asbestos paper washers 0.03125 in. (0.75 mm) thick, of outside diameter to fit securely in the burner tops, shall be inserted within the burner tops in positions No. 14 through No. 33. Hole diameter in the washers to graduate the openings shall be as follows:

Hole No. (from front end)	Diameter, in. (mm)
14, 15	1.00 (25.4)
16, 17	0.875 (22.2)
18, 19	0.8125 (20.0)
20, 21	0.75 (19.0)
22, 23	0.6875 (17.5)
24, 25	0.625 (15.9)
26, 27	0.5625 (14.3)
28, 29	0.500 (12.7)
30, 31	0.4375 (11.1)
32, 33	0.375 (9.5)

4.4 The body of the furnace shall be constructed of 12-gage (2.05-mm), low-carbon steel lined with high temperature-grade asbestos millboard to a thickness of 1 in. (25.4 mm). The angle iron bed ((*3*) in Fig. 2) to hold the test specimen shall be tilted 30° from the horizontal, side to side. The hood and stack ((*6*) in Fig. 1) shall be of 16-gage (1.29-mm), low-carbon steel lined with asbestos millboard 0.25 in. (6.4 mm) thick. The stack of the furnace shall be located beneath a ventilating hood with sufficient draft to remove accumulating smoke. There should be no direct connection between the stack and ventilating hood since the only draft within the furnace shall be that developed from the burning of the heating gas and test specimen. The furnace shall be located so that there are no unusual drafts surrounding the furnace.

4.5 The temperature and smoke density o the combustion gases shall be measured in the stack. For the temperature measurement, two thermocouple junctions shall be embedded in a copper rod, 0.5 in. (12.7 mm) in diameter and 17.25 in. (438 mm) long, held horizontally in the stack. Temperatures of of the thermocouple junctions, connected in parallel, shall be measured by a potentiometer. Smoke density shall be determined with a photoelectric type of smoke meter, which indicates the reduction in the intensity of a column of light passing horizontally through the stack ((*7*) in Fig. 1) to a photoelectric cell.

4.6 The main burner located at the front end of firebox shall consist of a 1.25-in. (32-mm) T-head iron pipe in which are drilled two parallel rows of holes 90° apart. Each row shall have 53 holes 0.125 in. (3.2 mm) in diameter with centers 0.25 in. (6.4 mm) apart (Note 1). The burner shall be located in the firebox with the holes 13 in. (330 mm) from the front end and the top of the pipe 2.125 in. (28 mm) below the bottom surface of the steel partition. The igniting burner shall be located 0.5 in. (12.7 mm) below and parallel to the face of the test specimen and 1 in. (25.4 mm) from the lower side of the specimen.

NOTE 1—This burner is suitable for natural gas. For bottled and manufactured gases, the burner construction may have to be altered.

5. Test Specimen

5.1 The test specimen shall be 13.75 in. (349 mm) wide by 8 ft (2.44 m) long and conditioned to a constant weight at a temperature of 75 ± 5°F (24 ± 2.8°C) and a relative humidity from 35 to 40 %.

6. Comparison Standards

6.1 The red oak comparison standard to which the index value of 100 is arbitrarily assigned shall consist of plain-sawed, select-grade red oak flooring selected with the density range from 37.0 to 42.0 lb/ft^3 (592 to 672 kg/m^3). The flooring shall be nailed to a backing of plywood 0.25 in. (6.4 mm) thick.

6.2 The asbestos millboard comparison standard to which the index value of 0 is arbitrarily assigned shall be 0.25 in. (6.4 mm) thick and of sufficiently high quality to withstand the test conditions without sagging.

7. Procedure

7.1 Before installing a test specimen, measure the temperature at the top surface of the steel partition ((*5*) in Fig. 2) at a point midway between the sides of the partition and the ends of the specimen opening. Measure the temperature by means of a thermocouple junction placed at the designated point and covered by an asbestos pad 0.4 in. (10.2 mm) thick and 6 in. (152 mm) square. If, after a period of at least 2 min, the temperature is not 85 ± 5°F (29.4 ± 2.8°C), a preheating flame (such as from the main burner) or a cooling draft (such as from a fan) may be used in the firebox to obtain the desired temperature.

7.2 When the temperature of the partition is within the prescribed limits, lay the test specimen on the angle iron frame ((*3*) in Fig. 2). Then lay the specimen cover ((*8*) in Fig. 2) over the specimen in the same frame and clamp it in place, checking the seal of the cover in the sand trough ((*2*) in Fig. 2) and adding necessary sand.

7.3 Adjust the valve to the main burner to supply gas at a rate (Note 2) such that the time for the flames to travel the length of the standard red oak specimen is 19.0 ± 1.0 min (Note 3). Adjust the atmospheric injector air-gas mixing unit so that the supply of primary air is adequate to produce a blue flame.

NOTE 2—A gas rate with a computed heating value of 3400 Btu/min is suggested for initial trials.

NOTE 3—There will be a decided increase in the emissivity of the stainless steel partitioning plate during the first ten runs and, therefore, final standardization should not be attempted until these runs have been completed.

7.4 Maintain the heating rate of the gas supplied to the main burner, once established and standardized, constant in all subsequent tests (Note 4) unless recalibration tests with the red oak standard indicate that the standard burning time is not within the 18 to 20-min period. Readjustment of the rate of heating and recalibration with the red oak standard to determine the standard test period shall then be necessary.

NOTE 4—This standardization of the heating rate can be established by obtaining the heating value from the supplier of the gas and then computing the required volume rate of flow from the equation:

$$V = P_1 T_2 Q / P_2 T_1 H$$

where

V = desired rate of gas flow in ft^3/min under the condition of use,
T_2 = absolute temperature of gas used, K (°C + 273°),
P_2 = absolute pressure of gas used, mm Hg (gage pressure plus barometer pressure),
Q = standardized heating rate for the tests, Btu/min, and
H = heat content of gas in Btu/ft^3 under given conditions of P_1 mm Hg and T_1 K.

7.5 Burn the gas in the igniting burner with no primary air at the rate of 85 Btu/min. The individual flames from the orifices in this burner play over the first 4 in. (102 mm) of an asbestos millboard specimen. Light both burners as simultaneously as possible, and start the stop watches at the instant of lighting.

7.6 Watch the progress of the flame through the observation holes located along the side of the furnace with the line of sight toward the center line of the specimen. As the flame front passes each observation hole, note the time and the distance traveled. Note temperatures and smoke densities every 30 s. Plot the observations in graphs as shown in Fig. 3. The maximum length of travel of the flame on the specimen shall be 87 in. (2210 mm) (Note 5). The average time for the flame to travel this distance on the red oak standard (19.0 ± 1 min depending on furnace characteristics) becomes the standard test period. Run all subsequent tests for this entire period regardless of position of flame on specimen so as to obtain heat and smoke values for this standard period. Recalibration of this fur-

nace by making red oak standard tests shall be done as frequently as judged necessary, and the standard test period adjusted when necessary.

NOTE 5—The exposed length of the specimen is 94.5 in. (2410 mm). The igniting flame plays over the first 4.0 in. (101.6 mm). The end point shall be taken at 91 in. (2311 mm) from the first exposed part of the specimen or 87 in. (2210 mm) from the igniting flame. The last exposed 3.5 in. (89 mm) of specimen will therefore be disregarded.

8. Calculations

8.1 *Flame Spread Index*—Express the flame spread as an index relative to the rate on red oak standard with an index of 100, and on asbestos board with an index of 0. Express the flame spread index (I_s) in either of two ways (Fig. 3(*a*)), depending on whether the flame has reached the end of the test specimen in a shorter or longer time than on red oak.

8.1.1 For flame spread faster than on red oak:

$$I_s = (T_o/T_s) \times 100$$

where:

T_o = time to reach end of red oak specimen, and

T_s = time to reach end of test specimen.

8.1.2 For flame spread slower than on red oak:

$$I_s = (D_s/D_o) \times 100$$

where:

D_s = distance reached on test specimen in test period, in. (mm), and

D_o = distance reached on red oak in test period, 87 in. (2210 mm).

8.2 *Fuel Contributed Index*—Obtain the fuel contributed index (I_c) by planimetering the areas under the curves indicated in Fig. 3(*b*) and calculating the index value as follows:

$$I_c = [(A_s - A_a)/(A_o - A_a)] \times 100$$

where:

A_s = area under specimen curve for standard test period,

A_a = area under asbestos curve for standard test period, and

A_o = area under red oak curve for standard test period.

8.3 *Smoke Density Index*—Obtain the smoke density index (I_d) by planimetering the curves indicated in Fig. 3(*c*), and calculating the index value as follows:

$$I_d = [(A_s - A_a)/(A_o - A_a)] \times 100$$

where:

A_s = area under specimen curve for standard test period,

A_a = area under asbestos curve for standard test period, and

A_o = area under red oak curve for standard test period.

9. Report

9.1 Report the following information:

9.1.1 Identification of the test specimen including manufacturer and code designation and, when known, the thickness, density, and composition of the specimen.

9.1.2 Description of the method of mounting the test specimen within the furnace.

9.1.3 Identification, when known, of the composition, thickness or weight retained of any chemicals added or coating applied to the test specimen.

9.1.4 Moisture content of the test specimen at start of test.

9.1.5 Flame spread index, fuel contributed index, and smoke index as calculated in Section 8. Including flame travel, temperature, and smoke density data taken during the test.

9.1.6 Record of observations made during the test as to appearance of flame, char pattern, and any intumescence, or disintegration of test specimen or applied coatings.

9.1.7 Report all deviations from the standard method.

10. Precision and Bias

10.1 A precision and bias statement is being developed.