NFPA 255

Standard Method of Test of Surface Burning Characteristics of Building Materials

2000 Edition

NFPA

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

IMPORTANT NOTICE ABOUT THIS DOCUMENT

NFPA codes, standards, recommended practices, and guides, of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards.

The NFPA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this document available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the NFPA list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

NOTICES

All questions or other communications relating to this document and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA documents during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

Users of this document should be aware that this document may be amended from time to time through the issuance of Tentative Interim Amendments, and that an official NFPA document at any point in time consists of the current edition of the document together with any Tentative Interim Amendments then in effect. In order to determine whether this document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments, consult appropriate NFPA publications such as the *National Fire Codes®* Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed above.

A statement, written or oral, that is not processed in accordance with Section 5 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

The NFPA does not take any position with respect to the validity of any patent rights asserted in connection with any items which are mentioned in or are the subject of this document, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Users of this document should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

Licensing Policy

NFPA 255

Standard Method of Test of

Surface Burning Characteristics of Building Materials

2000 Edition

This edition of NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, was prepared by the Technical Committee on Fire Tests and acted on by the National Fire Protection Association, Inc., at its November Meeting held November 14–17, 1999, in New Orleans, LA. It was issued by the Standards Council on January 14, 2000, with an effective date of February 11, 2000, and supersedes all previous editions.

This edition of NFPA 255 was approved as an American National Standard on February 11, 2000.

Origin and Development of NFPA 255

The test procedure covered by this standard was originally developed by Underwriters Laboratories Inc., and a descriptive article on the procedure was published in the *NFPA Quarterly* in July 1943. Subsequently, the test method was considered by Committee E-5 of the American Society for Testing and Materials and adopted by the ASTM as a tentative standard in 1950. Subsequent to NFPA action on this standard, on recommendation of the Committee on Building Construction in 1953, a new NFPA Committee on Fire Tests was created to provide the machinery for NFPA action on fire test standards in cooperation with the American Society for Testing and Materials. At the 1955 NFPA Annual Meeting, the Committee on Fire Tests, by a divided vote, recommended continuing tentative status, but, in view of the recommendation of the NFPA Committee on Building Construction and also of the NFPA Committee on Safety to Life, which use this standard in connection with interior finish requirements *(see NFPA 101®, Life Safety Code®)*, the standard was officially adopted in 1955. Revised editions were released in 1958, 1961, 1966, 1969, 1972, 1979, 1984, 1990, and 1996.

The 1996 edition of NFPA 255 contained minor revisions that included the method of calculating the test results and some editorial revisions. Plans to study the effect of the retaining element used to support test specimens within the test chamber were in progress; future editions would reflect these findings.

The 2000 edition contains only minor changes including those on substrate in B-9 that recognize the type of substrate used with a wall covering. There has been activity in NFPA *101®*, *Life Safety Code®*, related to the study on using the retaining element. Also a new standard, NFPA 286, *Standard Methods of Fire Tests for Evaluating Room Contribution of Wall and Ceiling Interior Finish to Fire Growth*, was developed that could be used for those materials that are not able to be tested to NFPA 255.

Technical Committee on Fire Tests

Jesse J. Beitel, *Chair*
Hughes Assoc., Inc., MD [SE]

Patty K. Adair, American Textile Mfrs., Inst., DC [M]
April L. Berkol, Starwood Hotels and Resorts, Inc., NY [U]
Rep. American Hotel & Motel Assn.
John A. Blair, The DuPont Co., DE [M]
Rep. Society of the Plastics Industry Inc.
William E. Fitch, Omega Point Laboratories Inc., TX [RT]
Thomas W. Fritz, Armstrong World Industries Inc., PA [M]
James R. Griffith, Southwest Research Inst., TX [RT]
Gordon E. Hartzell, Hartzell Consulting, Inc., TX [SE]
Marcelo M. Hirschler, GBH Int'l, CA [SE]
Alfred J. Hogan, Reedy Creek Improvement District, FL [E]
Rep. Int'l Fire Marshals Assn.
William E. Koffel, Jr., Koffel Assoc. Inc., MD [SE]
James R. Lawson, U.S. Nat'l Inst. of Standards & Technology, MD [RT]
Gerald E. Lingenfelter, American Insurance Services Group Inc., NY [I]
Rodney A. McPhee, Canadian Wood Council, ON, Canada [M]
William S. Metes, Underwriters Laboratories Inc., IL [RT]
James A. Milke, University of Maryland, MD [SE]
John Roberts, Underwriters Laboratories of Canada, ON, Canada [RT]
Nigel R. Stamp, Intertek Testing Services NA Inc., WI [RT]
Phil M. Stricklen, Amoco Fabrics and Fibers, GA [M]
Kuma Sumathipala, American Forest & Paper Assn., DC [M]
T. Hugh Talley, Hugh Talley Co., TN [M]
Rep. Upholstered Furniture Action Council
David K. Tanaka, Factory Mutual Research Corp., MA [I]
Richard P. Thornberry, The Code Consortium, Inc., CA [SE]
William A. Webb, Performance Technology Consulting, Ltd, IL [SE]
Robert A. Wessel, Gypsum Assn., DC [M]
Robert J. Wills, American Iron & Steel Inst., AL [M]
Peter J. Gore Willse, HSB Industrial Risk Insurers, CT [I]

Alternates

Kenneth G. Adams, The Society of the Plastics Industry, DC [M]
(Alt. to J. A. Blair)
Robert G. Bill, Jr., Factory Mutual Research Corp., MA [I]
(Alt. to D. K. Tanaka)
Delbert F. Boring, Jr., American Iron & Steel Inst., OH [M]
(Alt. to R. J. Wills)
Tony Crimi, Underwriters Laboratories of Canada, ON, Canada [RT]
(Alt. to J. Roberts)
Philip J. DiNenno, Hughes Assoc., Inc., MD [SE]
(Alt. to J. J. Beitel)
Sam W. Francis, American Forest & Paper Assn., PA [M]
(Alt. to K. Sumathipala)
Richard G. Gann, U.S. Nat'l Inst. of Standards & Technology, MD [RT]
(Alt. to J. R. Lawson)
Marc L. Janssens, Southwest Research Inst., TX [RT]
(Alt. to J. R. Griffith)
John W. Michener, Milliken Research Corp., SC [M]
(Alt. to P. K. Adair)
Frederick W. Mowrer, University of Maryland, MD [SE]
(Alt. to J. A. Milke)
Gene V. Paolucci, Yasuda Fire & Marine Insurance Co. of America, NY [I]
(Alt. to G. E. Lingenfelter)
William A. Thornberg, HSB Industrial Risk Insurers, CT [I]
(Alt. to P. J. G. Willse)
James J. Urban, Underwriters Laboratories Inc., IL [RT]
(Alt. to W. S. Metes)
Joe Ziolkowski, American Furniture Mfrs. Assoc., NC [M]
(Alt. to T. H. Talley)

Nonvoting

Robert H. Barker, American Fiber Mfrs. Assn., DC [M]
(Alt. to T. L. Jilg)
James F. Hoebel, U.S. Consumer Product Safety Commission, MD [C]
Tod L. Jilg, Hoechst Celanese Corp., NC [M]
Rep. American Fiber Mfrs. Assn.
Rohit Khanna, U.S. Consumer Product Safety Commission, MD [C]
(Alt. to J. F. Hoebel)
James C. Norris, Couance Laboratories Ltd [SE]
Herman H. Spaeth, Novato, CA
(Member Emeritus)

Walter P. Sterling, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on fire testing procedures, for reviewing existing fire test standards and recommending appropriate action to NFPA; for recommending the application of and advising on the interpretation of acceptable test standards for fire problems of concern to NFPA technical committees and members; and for acting in a liaison capacity between NFPA and the committees of other organizations writing fire test standards. This Committee does not cover fire tests that are used to evaluate extinguishing agents, devices, or systems.

Contents

NFPA 255

Standard Method of Test of

Surface Burning Characteristics of Building Materials

2000 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 4, Section D-9, and Appendix E.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Chapter 1 General

1-1 Scope. This method of testing surface burning characteristics of building materials is applicable to any type of building material that, by its own structural quality or the manner in which it is applied, is capable of supporting itself in position or is supported in the test furnace to a thickness comparable to its recommended use.

1-2 Purpose.

1-2.1 The purpose of the test is to determine the comparative burning characteristics of the material under test by evaluating the flame spread over its surface when exposed to a test fire, thus establishing a basis on which surface burning characteristics of different materials can be compared without specific consideration of all end-use parameters that might affect the surface burning characteristics.

1-2.2 The smoke density, as well as the flamespread rate, is recorded in this test. However, there is not necessarily a relationship between these measurements.

1-2.3* It is the intent of this method of test to register performance during the period of exposure, not to determine suitability for use after the test exposure.

1-2.4 This method does not establish ratings of standards of performance for specific uses, because these ratings depend on service requirements.

1-2.5 The values stated in U.S. customary units are to be regarded as the standard.

1-3 Definitions.

1-3.1 Shall. Indicates a mandatory requirement.

1-3.2 Should. Indicates a recommendation or that which is advised but not required.

Chapter 2 Test Equipment and Specimens

2-1 Fire Test Chamber.

2-1.1* The fire test chamber, shown in Figures 2-1.1(a) and (b), shall consist of a horizontal duct having an inside width of $17^3/_4$ in. ± $^1/_4$ in. (451 mm ± 6.3 mm), measured at the ledge location alongside walls, and $17^5/_8$ in. ± $^3/_8$ in. (448 mm ± 9.5 mm) at all other points; a depth of 12 in. ± $^1/_2$ in. (305 mm ± 12.7 mm) measured from the bottom of the test chamber to the ledge of the inner walls on which the specimen is supported [including the $^1/_8$-in. (3.1-mm) thickness of woven fiberglass gasketing tape]; and a length of 25 ft (7.62 m). The sides and base of the duct shall be lined with insulating masonry, consisting of A. P. Green G-26 refractory fire brick or equivalent, as illustrated by Figure 2-1.1(b). One side shall be provided with double observation windows with the inside pane flush mounted *[see Figure 2-1.1(b)]*. Exposed inside glass shall be $2^3/_4$ in. ± $^3/_8$ in. × 11 in. + 1 in./−2 in. (70 mm ± 9.5 mm × 279 mm + 25.4 mm/−51 mm). The centerline of the exposed area of the inside glass shall be in the upper half of the furnace wall, with the upper edge not less than 2.5 in. (61.9 mm) below the furnace ledge. The window shall be located so that not less than 12 in. (305 mm) of the specimen width can be observed. Multiple windows shall be located along the tunnel so that the entire length of the test sample is able to be observed from outside the fire chamber. The windows shall be pressuretight as described in 2-3.2.

2-1.2* The ledges shall be fabricated of structural materials capable of withstanding the abuse of continuous testing, shall be level with respect to the length and width of the chamber and each other, and shall be maintained in a state of repair commensurate with the frequency, volume, and degree of testing at all times.

2-1.3* To provide air turbulence for proper combustion, turbulence baffling shall be provided by positioning six A. P. Green G-26 refractory fire bricks or equivalent [long dimension vertical, $4^1/_2$-in. (114-mm) dimension along the wall] along the side walls of the chamber at distances of 7 ft, 12 ft, and 20 ft ± $^1/_2$ ft (2.1 m, 3.7 m, and 6.1 m ± 0.02 m) on the window side and $4^1/_2$ ft, $9^1/_2$ ft, and 16 ft ± $^1/_2$ ft (1.4 m, 2.9 m, and 4.9 m ± 0.02 m) on the opposite side.

2-1.4* The top lid shall consist of a removable noncombustible (metal and mineral composite) structure, insulated with nominal 2-in. (51-mm) thick mineral composition material as shown in Figure 2-1.1(b), and shall be of a size necessary to cover the fire test chamber and the test samples completely. The lid shall be maintained in an unwarped and flat condition. The mineral composition material shall have physical characteristics comparable to the following:

Maximum effective temperature, 1200°F (649°C)

Bulk density, 21 lb/ft^3 (336 kg/m^3)

Thermal conductivity, 0.50 Btu·in./hr·ft^2·°F to 0.71 Btu·in./hr·ft^2·°F

300°F to 700°F (149°C to 371°C), (0.072 W/m·K)

KpC product:

$$1 \text{ to } 4\ \frac{(\mathrm{Btu}^2\cdot \mathrm{in.})}{\mathrm{ft}^5\cdot \mathrm{h}\cdot {}^\circ\mathrm{F}^2}\left(1\times 10^4 \text{ to } 4\times 10^4\ \frac{\mathrm{W}^2\cdot \mathrm{S}}{\mathrm{m}^4\cdot \mathrm{K}^2}\right)$$

where KpC is equal to the thermal conductivity times the density times the specific heat.

The entire lid assembly shall be protected with flat sections of high-density [nominal 110 lb/ft^3 (1762 kg/m^3)] $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board, maintained in an unwarped and uncracked condition through continued replacement. This protective board shall be permitted to be either secured or not secured to the furnace lid. When in place, the top shall be sealed completely against the leakage of air into the fire test chamber during the test.

FIGURE 2-1.1(a) Fire test chamber.

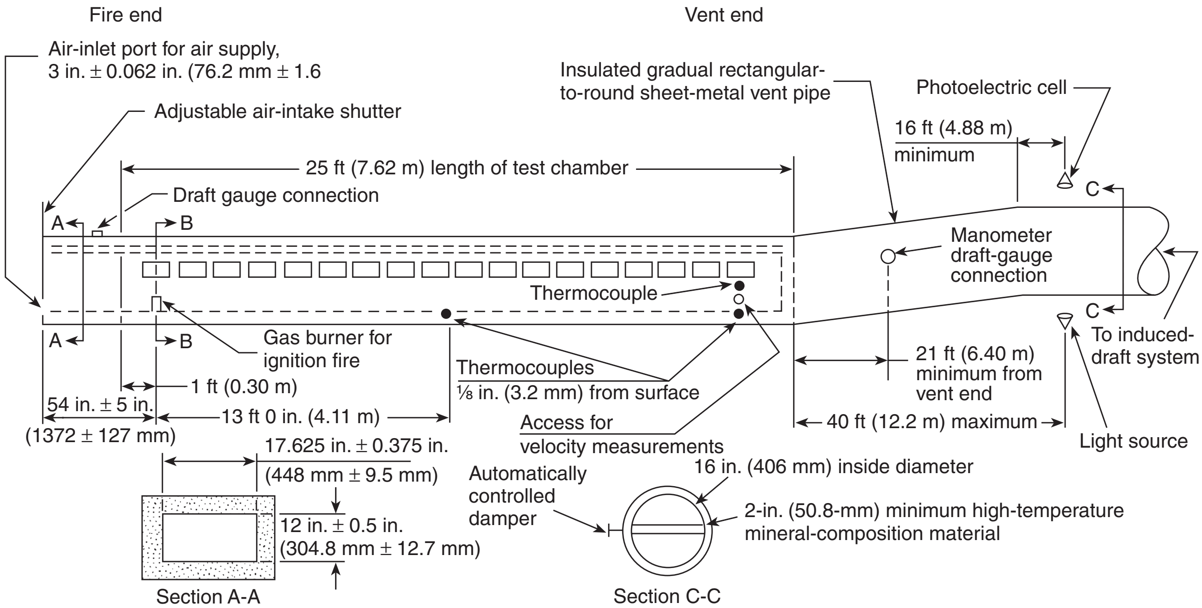
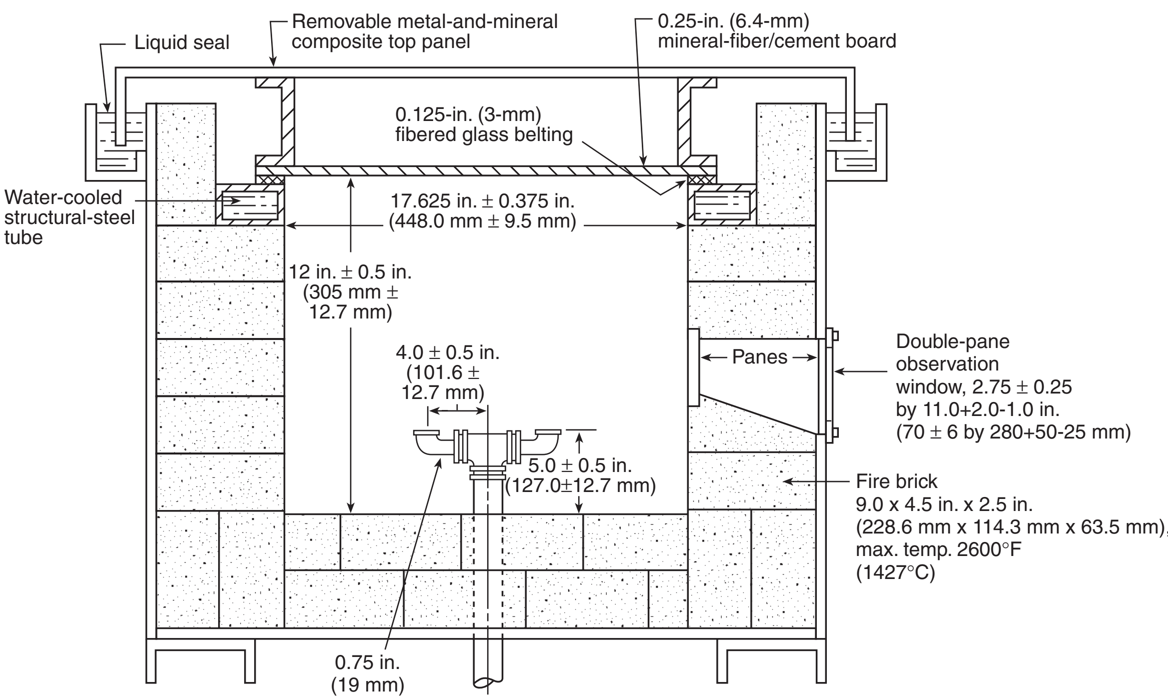


FIGURE 2-1.1(b) Fire test chamber, side view.



2-1.5 One end of the test chamber, designated as the fire end, shall be provided with two gas burners delivering flames upward against the surface of the test sample. The burners shall be spaced 12 in. (305 mm) from the fire end of the test chamber, and 7 in. ± $^1/_2$ in. (178 mm ± 12.7 mm) below the undersurface of the test sample. The air intake shutter shall be located 54 in. ± 5 in. (1372 mm ± 127 mm) upstream of the burner, as measured from the burner centerline to the outside surface of the shutter. Gas to the burners shall be provided through a single inlet pipe, distributed to each port burner through a tee section. The outlet shall be a $^3/_4$-in. (19-mm) elbow. The plane of the port shall be parallel to the furnace floor so that the gas is directed up toward the specimen. Each port shall be positioned with its centerline 4 in. ± $^1/_2$ in. (102.0 mm ± 12.7 mm) from each side of the centerline of the furnace so that the flame is evenly distributed over the width of the exposed specimen surface *[see Figure 2-1.1(b)]*.

The controls used to ensure a constant flow of gas to the burners during the period of use shall consist of a pressure regulator, a gas meter calibrated to read in increments of not more than 0.1 ft^3 (2.8 L), a manometer to indicate gas pressure in inches of water, a quick-acting gas shutoff valve, a gas metering valve, and an orifice plate in combination with a water manometer to assist in maintaining uniform gasflow conditions. An air intake fitted with a vertically sliding shutter extending the entire width of the test chamber shall be provided at the fire end. The shutter shall be positioned to provide an air inlet port 3 in. ± $^1/_{16}$ in. (76 mm ± 1.6 mm) high, measured from the floor level of the test chamber, at the air intake point.

2-1.6 The other end of the test chamber, designated as the "vent end," shall be fitted with a gradual rectangular-to-round transition piece of not less than 20 in. (508 mm) in length and having a cross-sectional area of 200 $in.^2$ (129,000 mm) at any point. The transition piece shall, in turn, be fitted to a flue pipe 16 in. (406 mm) in diameter. The movement of air shall be by an induced draft system having a total draft capacity of at least 0.15 in. (3.8 mm) water column with the sample in place, the shutter at the fire end open to the normal 3 in. ± $^1/_{16}$ in. (76 mm ± 1.6 mm), and the damper in the fully open position. A draft gauge to indicate static pressure shall be inserted through the top at the midwidth of the tunnel, 1 in. ± $^1/_2$ in. (25.4 mm ± 12.7 mm) below the ceiling, 15 in. ± $^1/_2$ in. (381 mm ± 12.7 mm) downstream from the inlet shutter.

2-1.7* A photometric system consisting of a light source and photocell shall be mounted on a horizontal section of the 16-in. (406-mm) diameter vent pipe at a point where it is preceded by a straight run of pipe [at least 12 diameters or 16 ft (4.88 m) and not more than 30 diameters or 40 ft (12.2 m)] from the vent end of the chamber, and with the light beam directed upward along the vertical axis of the vent pipe. The vent pipe shall be insulated with at least 2 in. (51 mm) of high-temperature mineral composition material from the vent end of the chamber to the photometer location. A photoelectric cell with an output that is directly proportional to the amount of light received shall be mounted over the light source and connected to a recording device having a minimum operating chart width of 5 in. (127 mm) with an accuracy within ±1 percent of full scale for the purpose of indicating changes in the attenuation of incident light caused by the passing smoke, particulate, and other effluent. The distance between the light source lens and the photocell lens shall be 36 in. ± 4 in. (914 mm ± 102 mm). The cylindrical light beam shall pass through 3-in. (76-mm) diameter openings at the top and bottom of the 16-in. (406-mm) diameter openings at the top and bottom of the 16-in. (406-mm) diameter duct, with the resultant light beam centered on the photocell.

2-1.8 The linearity of the photometer system shall be verified periodically by interrupting the light beam with calibrated neutral density filters. The filters shall cover the full range of the recording instrument. Transmittance values measured by the photometer, using neutral density filters, shall be within ±3 percent of the calibrated value for each filter.

2-1.9 An automatically controlled damper to regulate the draft pressure shall be installed in the vent pipe downstream of the smoke-indicating attachment. The damper shall be provided with a manual override.

2-1.10 Other manual, automatic, or combination manual and automatic draft regulation devices shall be permitted to be incorporated to maintain fan characterization and airflow control throughout test periods.

2-1.11 A No. 18 AWG (1.02-mm) thermocouple with $^3/_8$ in. ± $^1/_8$ in. (9.5 mm ± 3.1 mm) of the junction exposed in the air shall be inserted through the floor of the test chamber so that the tip is 1 in. ± $^1/_{32}$ in. (25.4 mm ± 0.8 mm) below the top surface of the woven fiberglass gasketing tape and 23 ft ± $^1/_2$ in. (7.0 m ± 12.7 mm) from the centerline of the burner ports, at the center of the burner width.

2-1.12 A No. 18 AWG (1.02-mm) thermocouple embedded $^1/_8$ in. (3.1 mm) below the floor surface of the test chamber shall be mounted in refractory or portland cement, carefully dried to avoid cracking, at distances of 13 ft ± $^1/_2$ in. (3.96 m ± 12.7 mm) and 23$^1/_4$ ft ± $^1/_2$ in. (7.09 m ± 12.7 mm) from the centerline of the burner ports.

2-1.13 The room in which the test chamber is located shall have provision for a free inflow of air during the test to maintain the room at atmospheric pressure during the entire test run.

2-2 Test Specimens.

2-2.1 The test specimen shall be at least 2 in. (51 mm) wider [nominally 20$^1/_4$ in. ± $^3/_4$ in. (514 mm ± 19 mm)] than the interior width of the tunnel and a total of 24 ft ± $^1/_2$ in. (7.32 m ± 12.7 mm) in length. The specimen shall be permitted to be one, continuous, unbroken length or to consist of sections joined end to end. A 14 in. ± $^1/_8$ in. (356 mm ± 3.1 mm) length of uncoated 16-gauge (0.053-in. to 0.060-in.) steel sheet shall be placed on the specimen mounting ledge in front of and under the specimen in the upstream end of the tunnel. The specimen shall be truly representative of the material for which test results are desired. Properties adequate for identification of the materials or ingredients, or both, from which the test specimen is made shall be recorded.

2-2.2 The test specimen shall be conditioned to a constant weight at a temperature of 73.4°F ± 5°F (23°C ± 2.8°C) and at a relative humidity of 50 percent ± 5 percent.

2-3 Calibration of Test Equipment.

2-3.1 A $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board shall be placed on the ledge of the furnace chamber, and the removable lid of the test chamber then shall be placed in position.

2-3.2 With the $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board in position on top of the ledge of the furnace chamber and with the removable lid in place, a draft shall be established to produce a 0.15-in. (3.8-mm) water column reading on the draft manometer, with the fire end shutter open 3 in. ± $^1/_{16}$ in. (76 mm ± 1.6 mm), by manually setting the damper in relationship to the fan performance. The fire end shutter then shall be closed and sealed without changing the damper position. The manometer reading shall increase to at least 0.375 in. (9.53 mm), indicating that no excessive air leakage exists.

2-3.3 In addition, a supplemental leakage test shall be conducted periodically with the fire shutter and exhaust duct beyond the differential manometer tube sealed by placing a smoke bomb in the chamber. The bomb shall be ignited and the chamber pressurized to 0.375 in. ± 0.135 in. (9.53 mm ± 3.43 mm) water column. All points of leakage observed in the form of escaping smoke particles shall be sealed. A draft reading within the range of 0.055 in. to 0.085 in. (1.40 mm to 2.16 mm) water column shall be established. The required draft gauge reading shall be maintained throughout the test by the automatically controlled damper.

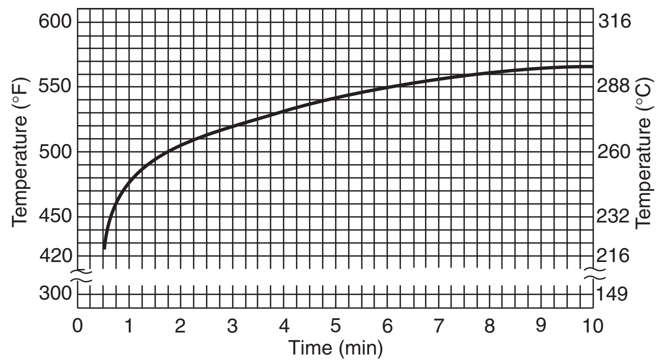
2-3.4* The air velocity shall be recorded at seven points, 23 ft (7.0 m) from the centerline of the burner ports, 6 in. ± $^1/_4$ in. (152 mm ± 6.3 mm) below the plane of the specimen mounting ledge. These seven points shall be determined by dividing the width of the tunnel into seven equal sections and recording the velocity at the geometric center of each section. During the measurement of velocity, the turbulence bricks *(see 2-1.3)* and the exposed 23-ft (7.0-m) thermocouple shall be removed and 24-in. (610-mm) long straightening vanes shall be placed 16 ft to 18 ft (4.88 m to 5.49 m) from the burner. The straightening vanes shall divide the furnace cross section into nine uniform sections. The velocity shall be determined with the furnace air temperature at 73.4°F ± 5°F (23°C ± 2.8°C) using a velocity transducer. The velocity, determined as the arithmetic average of the seven readings, shall be 240 ft/min ± 5 ft/min (73.2 m/min ± 1.5 m/min).

2-3.5 The air supply shall be maintained at 73.4°F ± 5°F (23°C ± 2.8°C) and the relative humidity at 50 percent ± 5 percent.

2-3.6 The fire test chamber shall be supplied with natural (municipal) or methane (bottled) gas fuel of uniform quality with a heating value of nominally 1000 Btu/ft^3 (37.3 MJ/m^3). The gas supply shall be adjusted initially at approximately 5000 Btu/min (5.3 MJ/min). The gas pressure, the pressure differential across the orifice plate, and the volume of gas used in each test shall be recorded. Unless otherwise corrected for, where bottled methane is used, a length of coiled copper tubing shall be inserted into the gas line between the supply and metering connection to compensate for possible errors in the indicated flow due to reductions in gas temperature associated with the pressure drop and expansion across the regulator. With the draft and gas supply adjusted as indicated in 2-3.3 and 2-3.6, the test flame shall extend downstream to a distance of 4$^1/_2$ ft (1.37 m) over the specimen surface, with negligible upstream coverage.

2-3.7 The test chamber shall be preheated with the $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board and the removable lid in place and with the fuel supply adjusted to the required flow. The preheating shall be continued until the temperature indicated by the floor thermocouple at 23$^1/_4$ ft (7.09 m) reaches 150°F ± 5°F (66°C ± 2.8°C). During the preheat test, the temperatures indicated by the thermocouple at the vent end of the test chamber shall be recorded at intervals not longer than 15 seconds, and these readings shall be compared to the preheat temperature shown in the temperature–time curve in Figure 2-3.7. The preheating is for the purpose of establishing the conditions that exist following successive tests that indicate the control of the heat input into the test chamber. If appreciable variation from the temperature shown in the representative preheat curve is observed, suitable adjustments in the fuel supply shall be permitted based on red oak calibration tests.

FIGURE 2-3.7 Temperature–time chart for preheat temperature.



2-3.8 The furnace shall be allowed to cool after each test. When the floor thermocouple at 13 ft (3.96 m) indicates a temperature of 105°F ± 5°F (40.5°C ± 2.8°C), the next specimen shall be placed in position for testing.

2-3.9 With the test equipment adjusted and conditioned as described in 2-3.2 through 2-3.8, a test or series of tests shall be made using nominal $^{25}/_{32}$-in. (19.8-mm) select grade red oak flooring as a specimen that has been conditioned to 6 percent to 8 percent moisture content as determined by the 221°F (105°C) oven dry method described in ASTM D 2016, *Tests for Moisture Content of Wood*. Observations shall be made at maximum distance intervals of 2 ft (0.61 m) and maximum time intervals of 30 seconds, and the time at which the flame reaches the end of the specimen that is 19$^1/_2$ ft (5.94 m) from the end of the ignition fire shall be recorded. The end of the ignition fire shall be considered to be 4$^1/_2$ ft (1.37 m) from the burners. The flame shall reach the end point in 5$^1/_2$ minutes ± 15 seconds. The temperatures measured by the thermocouple near the vent end shall be recorded at least every 15 seconds. The photoelectric cell output shall be recorded immediately prior to the test and at least every 15 seconds during the test. The flame shall be permitted to be considered as having reached the end point when the vent end thermocouple registers a temperature of 980°F (527°C).

2-3.10 The flame-spread distance, temperature, and change in photoelectric cell readings shall be plotted separately on suitable coordinate paper, as shown in Figures 2-3.10(a), (b), and (c), representative curves for red oak temperature–time, absorption–time smoke density, and distance–time flame spread, respectively. Flame spread shall be determined from the observed distance, less 4$^1/_2$ ft (1.37 m).

FIGURE 2-3.10(a) Temperature–time curve for red oak.

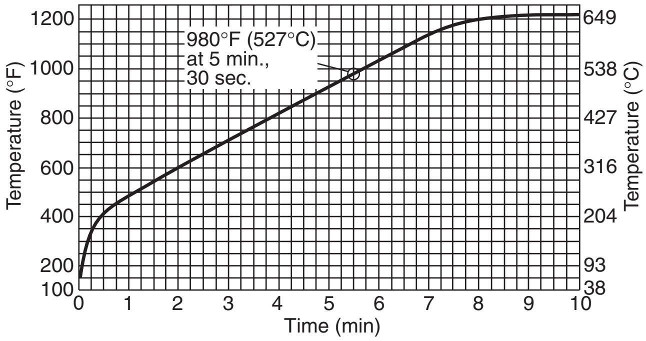


FIGURE 2-3.10(b) Absorption–time curve for smoke density of red oak.

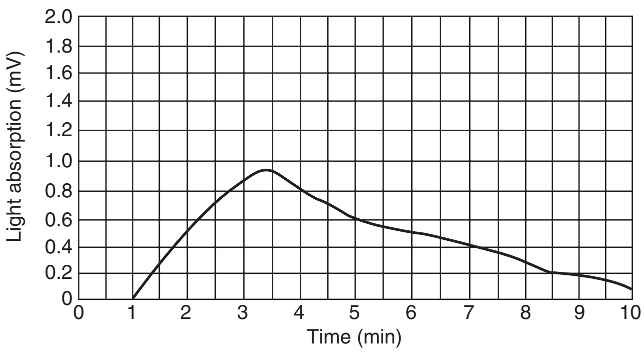
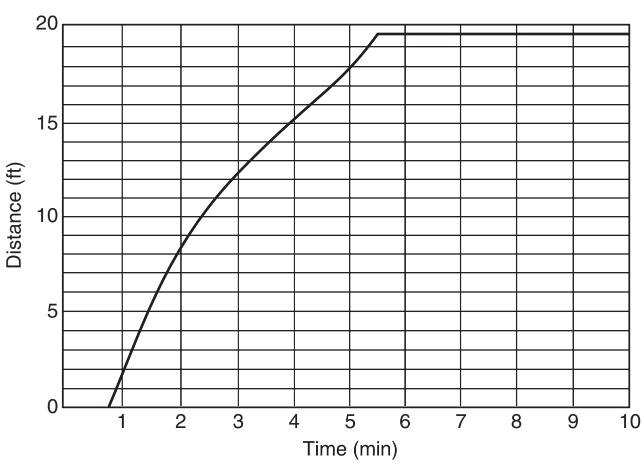
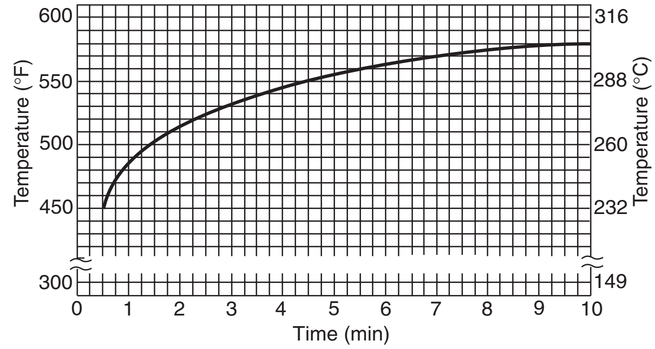


FIGURE 2-3.10(c) Distance–time curve for flame spread of red oak.



2-3.11 Following the calibration tests for red oak, a similar test or tests shall be conducted on samples of $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board. The results shall be considered as representing a classification of zero (0). The temperature readings shall be plotted separately on suitable coordinate paper, as shown in Figure 2-3.11, a representative curve for temperature-time development for inorganic-reinforced cement board.

FIGURE 2-3.11 Temperature–time curve for inorganic-reinforced cement board.



Chapter 3 Conduct of Tests

3-1 Test Procedure.

3-1.1 With the furnace draft operating, the test specimen shall be placed on the test chamber ledges that have been completely covered with nominal $^1/_8$ in. (3.1 mm) thick × $1^1/_2$ in. (38.1 mm) wide woven fiberglass tape. The specimen shall be positioned as quickly as is practicable. The removable lid shall be placed in position over the specimen.

3-1.2 The completely mounted specimen shall remain in position in the chamber with the furnace draft operating for 120 seconds ± 15 seconds prior to the application of the test flame.

3-1.3 The burner gas shall be ignited. The distance and time of maximum flame front travel shall be observed and recorded with the room darkened. The test shall continue for 10 minutes.

Exception: The test shall be permitted to be terminated prior to 10 minutes, provided the specimen is completely consumed in the fire area and no further progressive burning is evident and the photoelectric cell reading has returned to the baseline.

3-1.4 The photoelectric cell output shall be recorded immediately prior to the test and at least every 15 seconds during the test.

3-1.5 The gas pressure, the pressure differential across the orifice plate, and the volume of gas used for each test shall be recorded.

3-1.6 When the test is completed, the gas supply shall be shut off, smoldering and other conditions within the test duct shall be observed, and the specimen shall be removed for further examination.

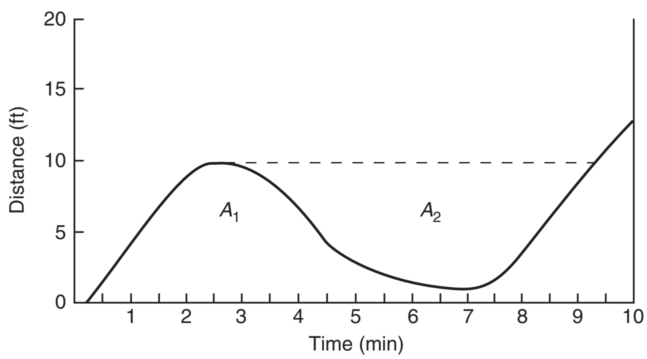
3-1.7 The flame-spread distance, temperature, and change in photoelectric cell readings shall be plotted separately on the same type of coordinate paper used in 2-3.10 in order to determine the flame spread and smoke development classifications outlined in Section 3-3. The flame-spread observations shall be recorded at maximum distance intervals of 2 ft (0.61 m) or maximum time intervals of 30 seconds. In addition, the peak and its time of occurrence shall be recorded. Flame spread shall be determined as the observed distance less $4^1/_2$ ft (1.37 m).

3-2 Analysis of Products of Combustion. Although not required as a part of this method, products of combustion shall be permitted to be drawn from the test duct for chemical analysis or during the test.

3-3 Classification. The flame-spread index (*FSI*) shall be determined as specified in 3-3.1 through 3-3.4.

3-3.1 The total area, A_T, under the flame-spread distance–time curve shall be determined by ignoring any flame front recession. For example, in Figure 3-3.1, the flame spread shown is 10 ft (3.05 m) in $2^1/_2$ minutes and then recedes. The area is calculated as though the flame had spread to 10 ft (3.05 m) in $2^1/_2$ minutes and then remained at 10 ft (3.05 m) for the remainder of the test or until the flame front again passed 10 ft (3.05 m) as indicated by the broken line in Figure 3-3.1. The area, A_T, used for calculating the flame-spread classification is the sum of areas A_1 and A_2 as shown.

FIGURE 3-3.1 Example of distance–time curve with flame front recession.



3-3.2 If the total area, A_T, is less than or equal to 97.5 min-ft (29.7 min-m), the flame-spread index equals 0.515 times the total area ($FSI = 0.515\ A_T$).

3-3.3 If the total area, A_T, is greater than 97.5 min-ft (29.7 min-m), the flame-spread index equals 4900 divided by the difference between 195 and the total area, A_T [$FSI = 4900/(195 - A_T)$].

3-3.4 The test results for smoke shall be plotted using the coordinates in Figures 2-3.10(a), (b), and (c). The area under the curve shall be divided by the area under the curve for red oak and multiplied by 100 to establish a numerical index by which the performance of the material can be compared with that of inorganic-reinforced cement board and select grade red oak flooring, which have been arbitrarily established as 0 and 100, respectively. Allowance shall be permitted to be made for accumulation of soot and dust on the photoelectric cell during the test by establishing a revised baseline. The revised baseline shall be a straight line drawn from the zero (0) point (point on baseline where incipient light attenuation occurs) to the point established after the sample has been removed.

3-4 Report. The report shall include all of the following:

(1) A description of the material being tested
(2) Test results as calculated in Section 3-3 and the following also shall apply:
    a. The individual flame-spread data values shall be rounded to the nearest multiple of 5 points.
    b. The individual smoke development data values shall be rounded to the nearest multiple of 5 points.
(3) Details of the method used in placing the specimen in the test chamber
(4) Observations of the burning characteristics of the specimen during test exposure such as, but not limited to, delamination, sagging, shrinkage, and fallout.

Chapter 4 Referenced Publication

4-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix E.

4-1.1 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 2016, *Tests for Moisture Content of Wood*, 1974 (discontinued).

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-2.3 See NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*, for procedures for determining the performance, under fire exposure conditions, of building constructions and materials where incorporated in a test structure and subject to a standard exposing fire of controlled extent and severity.

A-2-1.1 The following information can be useful in obtaining materials for the construction of the fire test chamber. The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees.

(1) Woven fiberglass tape, $1^1/_2$ in. × $^1/_8$ in. (38.1 mm × 3.1 mm), No. 8817K35 from McMaster-Carr, P.O. Box 54960, Los Angeles, CA 90054, or an equivalent, is suitable for this purpose.
(2) This method of lining the sides and base of the duct with insulating masonry is based on the use of G-26 fire brick manufactured by A.P. Green Refractories, Green Boulevard, Mexico, MO 65265.
(3) Double observation windows should be constructed of heat-resistant glass. Vycor, 100 percent silica glass, nominal $^1/_4$ in. (6.3 mm) thick, is suitable for the interior pane; Pyrex® glass, nominal $^1/_4$ in. (6.3 mm) thick, is suitable for the exterior pane.

A-2-1.2 High-temperature furnace refractory Zircon has been found suitable for this purpose.

A-2-1.3 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees. This method for turbulence baffling is based on the use of G-26 fire brick, manufactured by A. P. Green Refractories, Green Boulevard, Mexico, MO 65265.

A-2-1.4 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees. For inorganic-reinforced cement board, Manville Building Materials Corporation Flexboard II and Tunnel Building Products sterling board are suitable materials for this purpose.

A-2-1.7 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees. A Weston Instruments No. 856BB photronic cell and 12-V sealed beam, clear lens, autolamp with an overall light-to-cell path length of 36 in. ± 4 in. (914 mm ± 102 mm) is suitable for this purpose.

A-2-3.4 The following is being provided for informational purposes only and has not been independently verified, certified, or endorsed by NFPA or any of its technical committees. A Thermo Systems Inc. Model 1610 velocity transducer (thermal anemometer), using a readout device accurate to 0.001 V, is suitable for this purpose.

Appendix B Guide to Mounting Methods

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 Introduction.

B-1.1 This guide has been compiled as an aid in selecting a method for mounting various building materials in the fire test chamber. These mountings are recommended for test method uniformity and convenience; they are not meant to imply restriction in the specific details of field installation.

B-1.2 For some building materials, it is possible that none of the methods described are applicable. In such cases, other means of support might need to be devised.

B-1.3 These recommended mounting methods are grouped according to building materials to be tested that are identified broadly by either the usage or the form of the material.

B-1.4 Wherever inorganic-reinforced cement board is specified as a backing in subsequent paragraphs, the material should be nominal $^1/_4$ in. (6.3 mm) thick, high density [110 lb/ft^3 ± 5 lb/ft^3 (1762 kg/m^3 ± 80 kg/m^3)], and uncoated. Where metal rods are specified as supports, $^1/_4$-in. (6.3-mm) metal rods spanning the width of the tunnel should be used. Rods should be placed approximately 2 in. (51 mm) from each end of each panel, and additional rods should be placed approximately at 2-ft (0.61-m) intervals, starting with the first rod at the fire end of each panel.

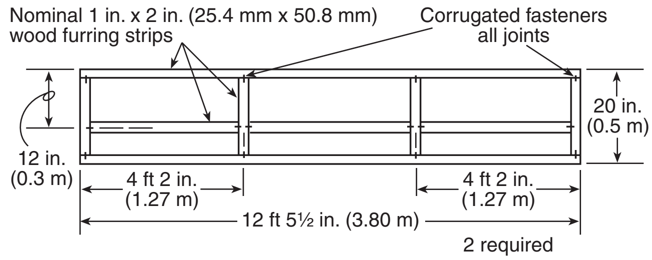
B-2 Acoustical and Other Similar Panel Products of Less Than 20 in. (508 mm).

B-2.1 For acoustical materials and other similar panel products with a maximum dimension of less than 20 in. (508 mm), metal splines or wood furring strips and metal fasteners should be used.

B-2.2 Steel tee splines for mounting kerfed-acoustical tile should be nominal $^1/_2$ in. (12.7 mm) web × $^3/_4$ in. (19 mm) flange, formed No. 24 MS gauge sheet metal.

B-2.3 Wood furring frames for mounting acoustical materials and other similar panel products of less than 20 in. (508 mm) should be nominal 1 in. × 2 in. (25.4 mm × 51 mm) wood furring joined with corrugated metal fasteners. Two frames should be used, as shown in Figure B-2.3.

FIGURE B-2.3 Wood frame for acoustical materials and other similar panel products of less than 20 in. (508 mm).



B-3 Adhesives. To determine the surface burning characteristics of adhesives, they are to be mixed as specified in the manufacturer's instructions and applied to inorganic-reinforced cement board in the thickness or at the coverage rate recommended by the manufacturer. The adhesive application should be cured prior to testing.

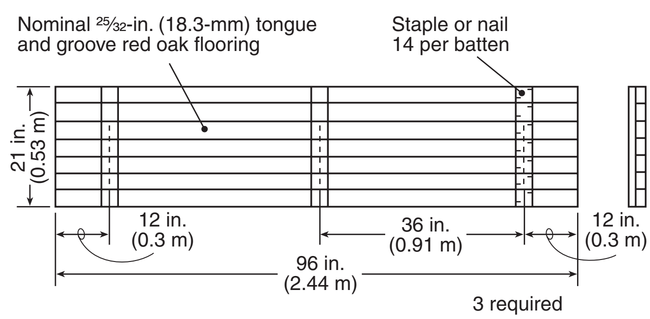
B-4 Batt- or Blanket-Type Insulating Materials. Batt or blanket materials that do not have sufficient rigidity or strength to support themselves should be supported by metal rods inserted through the material and positioned so that the bottom of the rod is approximately $^1/_4$ in. (6.3 mm) from the surface to be exposed to the flame. It is recommended that batt or blanket materials less than 1 in. (25.4 mm) thick not be mounted for testing in this manner.

B-5 Coating Materials, Cementitious Mixtures, and Sprayed Fibers.

B-5.1 Coating materials, cementitious mixtures, and sprayed fibers are to be mixed and applied to the substrate as specified in the manufacturer's instructions at the thickness, coverage rate, or density recommended by the manufacturer.

B-5.2 Materials intended for application to wood surfaces should be applied to a substrate made of nominal $^{25}/_{32}$-in. (19.8-mm) tongue and groove red oak flooring or to other materials for which the surface burning characteristic is to be measured. The pieces are placed side by side and secured with four nailing strips spaced approximately $3^1/_2$ ft (1.07 m) apart to hold the pieces together *(see Figure B-5.2)*. Two decks placed end to end are to be used.

FIGURE B-5.2 Wood deck for coating material.

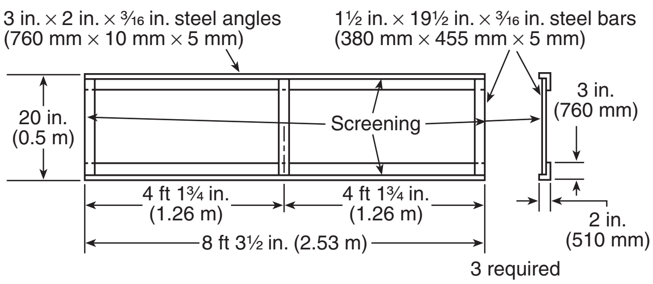


B-5.3 Materials intended for application to particular combustible surfaces, but not wood, should be applied to the specific surfaces for which they are intended.

B-5.4 Materials intended for field application to noncombustible surfaces only should be applied to $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board.

B-6 Loose Fill Insulation. Loose fill insulation should be placed on galvanized steel screening with openings of approximately $^3/_{64}$ in. (1.2 mm) supported on a test frame 20 in. (508 mm) wide × 2 in. (51 mm) deep, made from steel angles of 2 in. × 3 in. × $^3/_{16}$ in. (51 mm × 76 mm × 4.8 mm). Three frames are needed *(see Figure B-6)*. The insulation should be packed to the density specified by the manufacturer.

FIGURE B-6 Steel frame for loose fill materials.



B-7 Plastics.

B-7.1 The term *plastics* includes foams, reinforced panels, laminates, grids, and transparent or translucent sheets.

B-7.2 Where any plastic remains in position in the tunnel during a fire test, no additional support is necessary. Thermoplastic materials and other plastics that do not remain in place should be supported by $^1/_4$-in. (6.3-mm) round metal rods or $^3/_{16}$ in. (4.8 mm) thick × 2 in. (51 mm) wide steel bars, or 2-in. (51-mm) galvanized hexagonal wire mesh supported with metal bars or rods spanning the width of the tunnel.

B-8 Thin Membranes. Single-layer membranes of thin laminates consisting of a limited number of similar or dissimilar layers can be supported on poultry netting placed on metal rods as provided in Section B-4. Netting should be 20-gauge (51-mm) hexagonal galvanized steel poultry netting conforming to ASTM A 390, *Standard Specification for Zinc-Coated (Galvanized) Steel Poultry Fence Fabric (Hexagonal and Straight Line)*. The specimen should be tested while bonded to a substrate representative of a field installation.

B-9 Wall Coverings.

B-9.1 Whenever an adhesive is used to attach a wall covering, adhesives specified by the manufacturer should be used in the test in a manner consistent with field practice.

B-9.2 Wall coverings intended for application directly to a noncombustible wall surface should be mounted to $^1/_4$-in. (6.3-mm) inorganic-reinforced cement board unless tested in accordance with B-9.3 or B-9.4.

B-9.3 Wall coverings intended for application over gypsum board should be tested over $^5/_8$-in. (15.9-mm) type X gypsum wall board complying with ASTM C 36, *Standard Specification for Gypsum Wallboard*. There is no need to mount the gypsum wallboard on studs.

B-9.4 Wall coverings intended for application over any other substrate should be tested over that substrate.

B-9.5 Wall coverings not intended to be adhered directly to a wall surface, but suspended or otherwise supported by framing or a track system, should be mounted for test in a manner that is representative of their installation.

B-10 Bonding. Where the surface burning characteristics of the material itself are required, specimens should be mounted on inorganic-reinforced cement board with Sairmix No. 7 high-temperature bonding mortar or the equivalent. If the specimen cannot be adhered using Sairmix No. 7, Kentile No. 9 epoxy has been found to be a suitable alternative. The application should be determined by a $^3/_{32}$-in. (2.4-mm) notched trowel held at an 80 degree to 90 degree angle using a random pattern. The adhesive should be applied only to the specimen back. The specimen then should be placed on the smooth side of the inorganic-reinforced cement board and rolled using a 100-lb (54.4-kg) roller [nominal 5-in. (127-mm) long sections placed end to end for a total length of 15 in. (381 mm)]. The prepared samples can be dead-stacked overnight but should be transferred to separate storage racks until tested. Each sample should be vacuumed prior to testing.

NOTE 1: Sairmix No. 7 high-temperature bonding mortar is manufactured by A.P. Green Refractories, Green Boulevard, Mexico, MO 65265.

NOTE 2: Kentile No. 9 epoxy is manufactured by Kentile Floors, Inc., Brooklyn, NY 11215.

Appendix C Derivation of Flame-Spread Area Formulas in Section 3-3

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

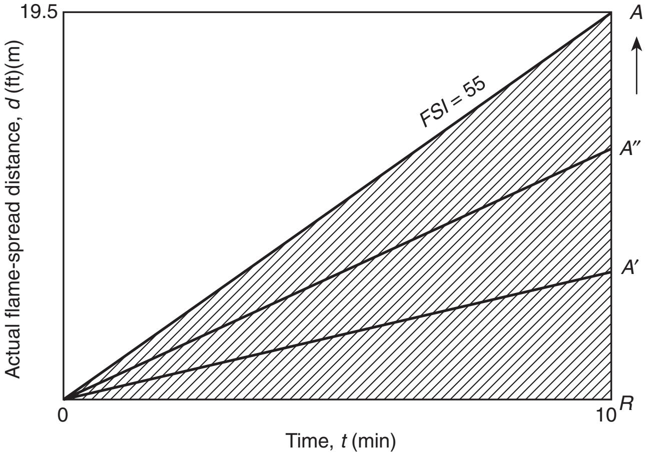
C-1 Introduction.

C-1.1 This appendix contains an abbreviated discussion of the derivations of the flame-spread area formulas used to calculate the flame-spread value in this test method. This appendix not only provides the derivations of the formulas but illustrates the relationship between this method of flame-spread calculation and a previous method.

C-1.2 In these calculations, it is assumed that the flame front never recedes. Therefore, in Figure 3-3.1, there is an imaginary line bordering the upper edge of area A_2.

C-2 Formula 1 Constant. In Figure C-2, an idealized straight-line flame-spread distance–time curve is plotted. The plots for $0A$, $0A'$, and $0A''$ create a combined area, $0RA$, $0RA$ having a maximum possible area of 97.5 min-ft ($^1/_2 \times 10$ min × 19.5 ft) [29.7 min-m ($^1/_2 \times 10$ min × 5.94 m)]. These straight-line plots represent a steady progression of the flame front to a maximum distance at the end of the 10-minute test.

FIGURE C-2 Idealized straight-line flame-spread distance–time curve for total areas less than or equal to 97.5 min-ft (29.7 min-m).



C-2.1 Where the flame front spreads for its maximum distance of 19.5 ft (5.94 m) in 10 minutes, a formula used in Section 3-3 would yield the following:

$$FSI = \frac{550}{t} = \frac{550}{10}$$

C-2.2 Where the flame front is maximized at 19.5 ft (5.94 m) in 10 minutes, the area in Figure C-2, 0*RA*, is maximized to 97.5 min-ft (29.7 min-m).

C-2.3 To relate the current formula, which is of the straight-line, origin intercept type, to the previous formula, it is necessary to express the two as follows:

$$FSI = \frac{550}{t} = KA$$

where:

K = the proportionality constant for equations of the current formula

A_T = the total area under area 0*RA*

if A_T = 97.5 min-ft at t = 10 min, then

$$FSC = \frac{550}{10} = K \times 97.5$$

and

$$K = \frac{550}{10 \times 97.5} = 0.564$$

NOTE: 97.5 min-ft = 29.7 min-m

C-2.4 Therefore, the formula in 3-3.2 for areas (A_T) of 97.5 min-ft (29.7 min-m) or less is as follows:

$$FSI = 0.564 A_T$$

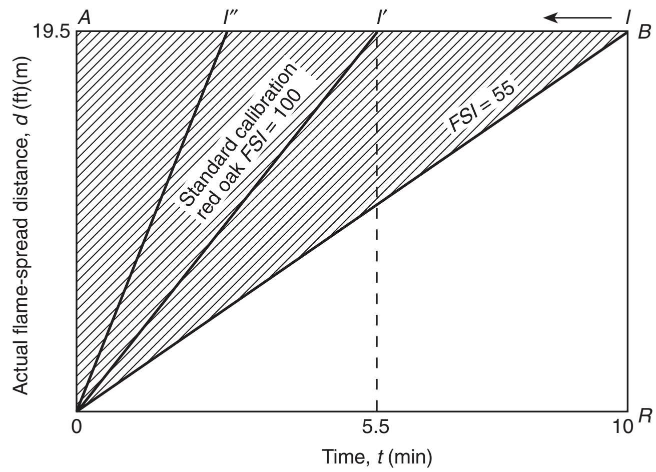
C-3 Formula 2 Constant. In the idealized straight-line flame-spread distance–time curve of Figure C-3, lines 0*I*, 0*I*', and 0*I*" create a group of trapezoidal areas, 0*RBI*, ranging from 97.5 min-ft to 195 min-ft (29.7 min-m to 59.4 min-m) [$^1/_2 \times 10$ min $\times$ 19.5 ft (59.4 m) to 10 min $\times$ 19.5 ft (59.4 m)]. This represents a flame front progression to the end of the specimen within the 10-minute test. The area (A_T) of 0*RBI* is expressed as follows:

$$\left(\frac{1}{2} \times 19.5 \times 0R\right) + \left[\frac{1}{2} \times 19.5 \times (10 - AI)\right]$$

which is equal to

$$195 - 9.75AI, \qquad \text{since } 0R \text{ is always 10 minutes.}$$

FIGURE C-3 Idealized straight-line flame distance–time curve for total areas greater than 97.5 min-ft (29.7 min-m).



C-3.1 The triangular area, 0*IA*, divided into a proportionality constant, *K*, determines the relationship between flame-spread values and the rate and distance of flame propagation. The total area available is 195 min-ft (59.4 min-m); therefore, area 0*IA* is equal to 195 0*RBI*. Thus, a new flame-spread formula can be derived as follows:

$$FSI = \frac{K}{0IA} = \frac{K}{195 - 0RBI} = \frac{K}{195 - A_T}$$

C-3.2 To establish *K*, a relationship between the current and previous formulas is established at the red oak calibration point of 19.5-ft (29.7-min-m) progression at 5.5 minutes as follows:

$$FSI = \frac{550}{1} = \frac{K}{195 - A_T}$$

where A_T = 195 – [9.75 (5.5)] = 141.38 min-ft and I = 5.5 minutes.

Thus:

$$FSI = \frac{550}{I} = \frac{K}{195 - 141.38}$$

or

$$K = \frac{550 \times (53.63)}{5.5} = 5363$$

C-4 Formulas 1 and 2.

C-4.1 To account for the disproportionate increase that can occur in *FSI* values at the lower end of the index scale, for K = 0.564 in Formula 1 and K= 5363 in Formula 2, a further mathematical modification is made.

C-4.2 To establish the relationship between the constants (K) in Sections C-2 and C-3, it is necessary to consider the forms of the basic formulas, which are as follows:

$$FSI = \frac{K_1}{195 - A_T} \quad (A > K_2)$$

$$FSI = K_3 A_T \quad (A < K_2)$$

where:

K_1 = $100(195 - R)$
R = the area under the curve that is to be associated with an index of 100
K_2 = an arbitrary choice within the limits of 0 and 195
K_3 = $K_1/[K_2(195 - K_2)]$

C-4.3 Choosing $K_2 = 195 \div 2$ produces a minimum value of K_3; that is, any other K_2 value will result in a higher K_3 value; and choosing R, the area under a red oak calibration plot, as a median value of 146 implies the following:

$$K_1 = 100(195 - 146) = 4900$$

C-4.4 Using 97.5 as the value for K_2, the formula for K_3 is as follows:

$$K_3 = \frac{4900}{97.5 \times 97.5} = 0.515$$

C-4.5 Therefore, the formula for the flame-spread index in 3-3.2 is as follows:

$$FSI = 0.515 A_T$$

C-4.6 Therefore, the formula for the flame-spread index in 3-3.3 is as follows:

$$FSI = \frac{4900}{195 - A_T}$$

Appendix D Commentary

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

D-1 Introduction.

D-1.1 This commentary has been prepared to provide the user of NFPA 255 with background information, including references, on the development and use of this method. It also provides the reader and user with the basis for the methods that have been used for deriving numerical flame-spread indexes, an appreciation of the variability of the test, and comments on its application and limitations for testing selected types of materials.

D-1.2 On November 28, 1942, four hundred ninety people died in a fire in the Coconut Grove Nightclub in Boston. On June 5, 1946, sixty-one people died in the La Salle Street Hotel fire in Chicago. On December 7, 1946, a fire in the Winecoff Hotel in Atlanta, Georgia, claimed the lives of one hundred nineteen people. These fires had one thing in common. In all three fires, rapid flame spread along the surfaces of interior finish was judged to be a major factor in fire growth. Two of the structures had burlap wall coverings, and the other had an early type of plywood that had seriously delaminated.

The fire protection authorities investigated several test methods with the objective of providing one that could be used to regulate interior finish materials and minimize repetition of such fires. These tests included the Forest Products Laboratory Fire Tube Test (now ASTM E 69, *Standard Test Method for Combustible Properties of Treated Wood by the Fire-Tube Apparatus*); Federal Specification SS A118b (acoustical tile/bunsen burner test, replaced by SS-A-118a-7/63, referencing ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*); New York City Timber Test and Shavings Test (now obsolete); the Crib Test, ASTM Specification C 160-41 T (now ASTM E 160, *Test Method for Combustible Properties of Treated Wood by the Crib Test*); and the Swedish Schlyter Test.[1] All were relatively small laboratory tests. ASTM E 84/NFPA 255 was developed on the premise that a large test would provide a more realistic and comprehensive test, and it has since been widely adopted for use by the building code authorities to regulate the use of interior finish materials.

Subsequently, during this same period, two other test methods were developed for use in the research and development of new materials: the NBS radiant panel test (ASTM E 162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*) and the FPL 8-foot tunnel test [ASTM E 286, *Test Method for Surface Flammability of Building Materials Using an 8-ft (2.44-m) Tunnel Furnace*]. These test methods have been widely used for research and development purposes.

D-2 History of ASTM E 84/NFPA 255.

D-2.1 The first tunnel-type furnace was built at Underwriters Laboratories around 1922, when fireproofing paints and specifically whitewash were actively promoted. The equipment consisted of a long bench with a noncombustible top. The sample consisted of a wood trough about 16 ft long × 18 in. wide × 18 in. deep (4.88 m long × 0.457 m wide × 0.457 m deep), placed upside down on the bench. The inside of the trough was coated with the paint. A known quantity of wood at one end furnished the ignition source.

D-2.2 In 1927 and 1928, chemically impregnated wood was being developed, and Underwriters Laboratories used a tunnel 36 in. wide × 23 ft long × 13 in. deep (0.914 m wide × 7.0 m long × 0.33 m deep) to evaluate its performance. It was during this time that red oak flooring was selected as a control to be used to calibrate the furnace. The sample formed the top of the tunnel. The fuel and draft also were controlled.

D-2.3 In the early 1940s, a desire to reduce the flammability of wood-based products and the introduction of new building materials and combinations of materials created a need to improve the tunnel further. The development of the third tunnel furnace is explained fully in Underwriters Laboratories