

NFPA 251

Standard Methods of Tests of Fire Resistance of Building Construction and Materials

2006 Edition



NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
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NFPA 251

Standard Methods of Tests of Fire Resistance of Building Construction and Materials

2006 Edition

This edition of NFPA 251, *Standard Methods of Tests of Fire Resistance of Building Construction and Materials*, was prepared by the Technical Committee on Fire Tests and acted on by NFPA at its June Association Technical Meeting held June 6–10, 2005, in Las Vegas, NV. It was issued by the Standards Council on July 29, 2005, with an effective date of August 18, 2005, and supersedes all previous editions.

This edition of NFPA 251 was approved as an American National Standard on August 18, 2005.

Origin and Development of NFPA 251

NFPA 251 originated in the recommendations of the International Fire Prevention Congress in London in 1903. It was presented to the NFPA by the Committee on Fire-Resistive Construction in 1914. It was adopted officially in a revised form in 1918. Successive editions were published in 1926, 1934, 1941, 1955, 1958, 1959, 1960, 1961, 1963, 1969, 1979, 1985, and 1990. It was overseen, in succession, by the Technical Committee on Fire-Resistive Construction, the Technical Committee on Building Construction, and, for the last three editions, by the Technical Committee on Fire Tests.

The 1995 edition of this document was a reconfirmation of the earlier edition with only a few items being addressed. Substantial investigation and record research was done on the topic of the hose stream application on test specimens. The findings of the committee did not support modification of the provision that permits a test assembly to be tested for one-half the time required for an hourly rating and then to be tested by a hose stream.

The committee also modified the title of this document in response to the research done to convey a truer sense of the standard's proper application.

The 1999 edition was a reconfirmation of the 1995 edition with minor editorial modifications.

The 2006 edition includes a complete editorial rewrite for compliance with the *Manual of Style for NFPA Technical Committee Documents*. The title of the document was revised to more accurately reflect the subject matter, and further organizational and editorial changes were made to improve the application of the test method. Technical changes include the addition of definitions of *fire resistance* and *fire resistance rating* and modifications to the hose stream test requirements.

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Fire Resistance of Building Construction
and Materials

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

Information on referenced publications can be found in Chapter 2 and Annex H.

Chapter 1 Administration

1.1* Scope. This standard provides methods of fire tests for the fire-resistive properties of building members and assemblies.

1.2 Purpose.

1.2.1 This standard describes methods to evaluate the duration for which the types of assemblies noted in 1.3.1 contain a fire, retain their structural integrity, or exhibit both properties, depending on the type of assembly involved during a predetermined test exposure.

1.2.2 It is the intention of this standard that fire resistance ratings be based on performance during the period of exposure and not be used to determine suitability for use after fire exposure.

1.2.3* The results of these tests are one factor in assessing fire performance of building construction and assemblies.

1.3 Application.

1.3.1 These methods of fire tests apply to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs, and composite slab and beam assemblies for floors and roofs.

1.3.2 They also apply to other assemblies and structural units that constitute permanent integral parts of a finished building.

1.3.3 This standard requires a specimen to be exposed to a standard fire exposure that is controlled to achieve specified temperatures throughout a specific time period.

1.3.4 In some instances, the fire exposure is followed by the application of a specified standard fire hose stream.

1.3.5 The exposure is not to be considered representative of all fire conditions, which vary with changes in the amount, nature, and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment.

1.3.6 The test provides a relative measure of fire performance of comparable assemblies under specified fire exposure conditions.

1.3.7 Variations in the construction or conditions (e.g., size, method of assembly, and materials) that are tested substantially vary the performance characteristics of the assembly.

1.3.8 The standard provides methods to measure the following:

- (1) In walls, partitions, and floor or roof assemblies:
 - (a) Transmission of heat
 - (b) Transmission of hot gases through the assembly sufficient to ignite cotton waste
 - (c) Load-carrying ability of the test specimen during the test exposure where load-bearing elements are included
- (2) For individual load-bearing assemblies such as beams and columns, a load-carrying ability under the test exposure with some consideration for the end support conditions (i.e., restrained or unrestrained)

1.3.9 The standard does not provide the following:

- (1) Full information on the performance of assemblies constructed with components or lengths other than those tested
- (2) Evaluation of the degree to which the assembly contributes to the fire hazard by generation of smoke, toxic gases, or other products of combustion
- (3) Measurement of the degree of control or limitation of the passage of smoke or products of combustion through the assembly
- (4) Simulation of the fire behavior of joints between building elements, such as floor-to-wall or wall-to-wall connections
- (5) Measurement of flame spread over the surface of the tested element
- (6) Effect on fire endurance of conventional openings in the assembly (e.g., electrical receptacle outlets, plumbing pipe) unless specifically provided for in the construction tested

1.4 Units. The U.S. customary (inch-pound) value for a measurement and the International System of Units (SI) value given in parentheses shall each be acceptable for use as primary units for satisfying the requirements of this standard.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. (Reserved)**2.3 Other Publications.**

2.3.1 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM C 569, *Test for Indentation Hardness of Preformed Thermal Insulations*, 1989.

ASTM E 2226, *Standard Practice for Application of Hose Stream*, 2002.

2.3.2 Other Publication. Merriam-Webster's *Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1 Shall. Indicates a mandatory requirement.

3.2.2 Should. Indicates a recommendation or that which is advised but not required.

3.2.3 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1* Fire Resistance. The measure of the ability of a material, product, or assembly to withstand fire or give protection from it.

3.3.2* Fire Resistance Rating. The time, in minutes or hours, that materials or assemblies have withstood a standard fire exposure. The rating should be determined in accordance with the test procedures of this standard.

Chapter 4 Control of Fire Tests

4.1 Temperature-Time Curve.

4.1.1* The conduct of fire tests of materials and construction shall be controlled by the standard temperature-time curve shown in Figure 4.1.1.

4.1.2 The temperature inside the furnace shall be ambient when the test begins.

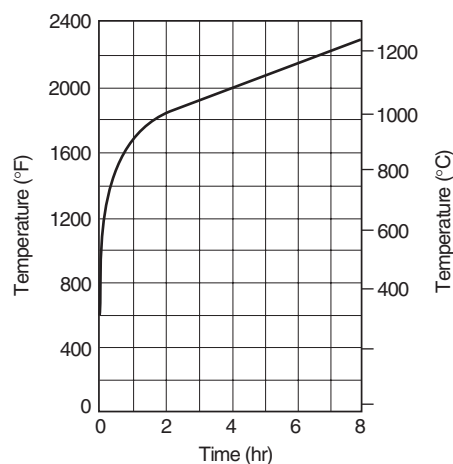
4.2* Furnace Temperatures.

4.2.1* The temperature fixed by the curve shall be the average temperature obtained from the readings of no fewer than nine thermocouples for a floor, roof, wall, or partition and no fewer than eight thermocouples for a structural column.

4.2.1.1 The thermocouples shall be symmetrically disposed and distributed to show the temperature near all parts of the sample and shall be enclosed in protection tubes of such materials and dimensions that the time constant of the protected thermocouple assembly lies within the range of 5.0 minutes to 7.2 minutes.

4.2.1.2 The exposed length of the pyrometer tube and the thermocouple in the furnace chamber shall be not less than 12 in. (305 mm).

4.2.1.3 Other types of protecting tubes or pyrometers shall be permitted to be used that, under test conditions, provide the time range of 5.0 minutes to 7.2 minutes within the accuracy requirement that applies for the measurement of furnace temperature.



1000°F (538°C)		at 5 minutes
1300°F (704°C)		at 10 minutes
1550°F (843°C)		at 30 minutes
1700°F (927°C)		at 1 hour
1850°F (1010°C)		at 2 hours
2000°F (1093°C)		at 4 hours
2300°F (1260°C)		at 8 hours or over

FIGURE 4.1.1 Temperature-Time Curve.

4.2.1.4 For floors and columns, the junction of the thermocouples shall be placed 12 in. (305 mm) away from the exposed face of the specimen at the beginning of the test and, during the test, shall not touch the sample as a result of its deflection.

4.2.1.5 In the case of walls and partitions, the thermocouples shall be placed 6 in. (152 mm) away from the exposed face of the specimen at the beginning of the test and shall not touch the specimen during the test in the event of deflection.

4.2.2 The temperatures shall be measured at intervals not exceeding 1 minute during the test period.

4.2.3 The accuracy of the furnace control shall be such that the area under the temperature-time curve, obtained by averaging the results from the pyrometer readings, is within the following percentages of the corresponding area under the standard temperature-time curve shown in Figure 4.1.1:

- (1) 10 percent for fire tests of 1 hour or less
- (2) 7.5 percent for fire tests over 1 hour and not more than 2 hours
- (3) 5 percent for fire tests exceeding 2 hours

4.3 Temperatures of Unexposed Surfaces of Floors, Roofs, Walls, and Partitions.

4.3.1* Temperatures of unexposed surfaces shall be measured with thermocouples or thermometers placed under thermocouple pads.

4.3.1.1 Thermocouple pads shall meet the following requirements or otherwise shall be demonstrated to be equivalent by comparative NFPA 251 tests:

- (1) Length and width, 6 in. $\pm$ 1/8 in. (152 mm $\pm$ 3.2 mm)
- (2) Thickness, 0.40 in. $\pm$ 0.05 in. (10.2 mm $\pm$ 1.3 mm)
- (3) Thermal conductivity [at 150°F (65°C)], 0.38 $\pm$ 0.027 Btu-in./hr-ft²·°F (0.55 $\pm$ 0.039 W/m·K)

- (4) Dry weight, $0.147 \text{ lb} \pm 0.053 \text{ lb}$ ($67 \text{ g} \pm 24 \text{ g}$)
 (5)*Hardness indentation on soft face, $0.075 \text{ in.} \pm 0.025 \text{ in.}$ ($1.9 \text{ mm} \pm 0.6 \text{ mm}$), with indentation determined in accordance with ASTM C 569, *Test for Indentation Hardness of Preformed Thermal Insulations*

4.3.1.2 The wire leads of the thermocouple or the stem of the thermometer shall have an immersion under the pad and shall be in contact with the unexposed surface for not less than $3\frac{1}{2} \text{ in.}$ (90 mm).

4.3.1.3 The hot junction of the thermocouple or the bulb of the thermometer shall be placed under the approximate center of the pad.

4.3.1.4 The outside diameter of protecting or insulating tubes and of thermometer stems shall be not more than $\frac{5}{16} \text{ in.}$ (8 mm).

4.3.1.5 The pad shall be held firmly against the surface and shall fit closely about the thermocouples or thermometer stems.

4.3.1.6 Thermometers shall be of the partial-immersion type, with a length of stem between the end of the bulb and the immersion mark of 3 in. (76 mm).

4.3.1.7 The wires for the thermocouple in the length covered by the pad shall be not heavier than No. 18 B&S gauge [0.04 in. (1.02 mm)] and shall be electrically insulated with heat-resistant and moisture-resistant coatings.

4.3.2 Temperature measurements shall be obtained from at least nine points on the surface, as follows:

- (1) Five thermocouples shall be symmetrically disposed as follows:
 - (a) One located approximately at the center of the specimen
 - (b) Four located approximately at the center of each quadrant
- (2) The other four thermocouples shall be located at the discretion of the testing authority to obtain representative information on the performance of the construction under test.
- (3) All the thermocouples shall be located at a distance at least $1\frac{1}{2}$ times the thickness of the construction or 12 in. (305 mm) from the edges of the test specimen.
- (4) The distance requirements specified in 4.3.2(3) shall not apply where an element of the assembly is located near the edge only.
- (5) None of the thermocouples shall be located opposite or on top of beams, girders, pilasters, or other structural members if temperatures at such points are lower than at more representative locations.
- (6) None of the thermocouples shall be located opposite or on top of fasteners such as screws, nails, or staples that are higher or lower in temperature than at more representative locations if the aggregate area of any part of such fasteners projected to the unexposed surface is less than 1 percent of the area within any 6 in. (152 mm) diameter circle.
- (7) The fasteners specified in 4.3.2(6) shall not be required to extend through the assembly.

4.3.3 Temperature readings shall be measured at intervals not exceeding 1 minute.

4.3.4 Where the conditions of acceptance place a limitation on the rise of the temperature of the unexposed surface, the temperature end point of the fire resistance period shall be

determined by the average of the measurements taken at individual points.

4.3.5 Where a temperature rise of 30 percent in excess of the specified limit occurs at any one of the individual measurement points, all other points shall be ignored, and the fire endurance period shall be judged as ended.

4.4 Furnace Pressure.

4.4.1 The pressure-sensing probes shall be as shown in Figure 4.4.1(a) or Figure 4.4.1(b).

4.4.2 The pressure shall be measured using a differential pressure instrument capable of reading in increments no coarser than 0.01 in. wg (2.5 Pa) with a precision of not less than $\pm 0.005 \text{ in. wg}$ ($\pm 1.25 \text{ Pa}$).

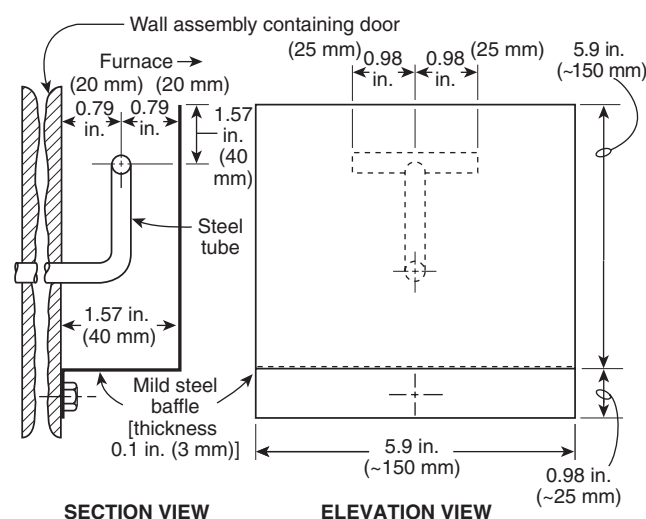


FIGURE 4.4.1(a) Static Pressure-Sensing Probe Dimensions.

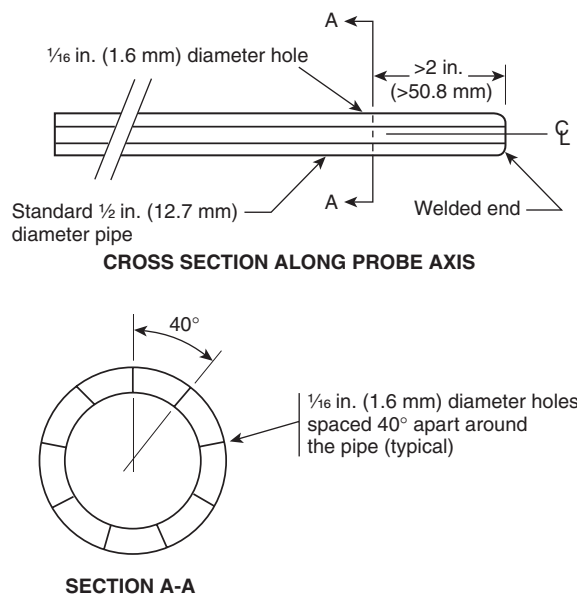


FIGURE 4.4.1(b) Pressure-Sensing Probe.

4.4.3 The differential pressure measurement instrument(s) shall be located to minimize stack effects caused by vertical runs of pressure tubing between the furnace probe(s) and instrument locations.

4.4.4 The furnace pressure(s) shall be measured and recorded at intervals not exceeding 1 minute throughout the test.

4.4.5 Control of the furnace pressure shall be established no later than 10 minutes after the start of the test and shall be maintained throughout the remainder of the test.

4.4.5.1 For vertical specimens, the vertical pressure distribution within the furnace shall be measured by at least two probes separated by a vertical distance [minimum of 6 ft (1.8 m)] within the furnace.

4.4.5.1.1 A calculation of the location of the neutral plane (zero differential pressure) shall be made based on the vertical separation of the probes and their pressure differences.

4.4.5.1.2 The pressure measurements made inside the furnace, along with the calculation showing the position of the neutral plane with respect to the top of the vertical assembly during the test, shall be reported.

4.4.5.2* For horizontal specimens, the following criteria shall be met:

- (1) The pressure shall be measured at two locations along the centerline of the specimen and 12 in. (305 mm) below the specimen.
- (2) The pressure (the average of the two readings) during the test shall be reported.

Chapter 5 Test Specimen

5.1 Specimen.

5.1.1 The test specimen shall be a true representation of the construction for which the fire resistance rating is to be determined with respect to materials, workmanship, and details such as dimension of parts.

5.1.1.1 The specimen shall be built under conditions representative of those properties that are applied in actual building construction and operation.

5.1.1.2 The physical properties of the materials and ingredients used in the test specimen shall be determined and recorded.

5.1.2 The following shall apply to the size and dimensions of the test specimen:

- (1) They shall be recognized as being intended to apply in rating constructions of dimensions within the normal general range used in buildings.
- (2) Where the conditions of use limit the construction to smaller dimensions, a proportionate reduction shall be permitted to be made in the dimensions of the specimens for a test used to qualify them for such restricted use.

5.1.3 Where it is desired to include a built-up roof covering, the following criteria shall be met:

- (1) The test specimen shall have a roof covering of 3-ply, 15 lb (6.8 kg) type felt not in excess of 120 lb (54.4 kg) per 100 ft² (9.3 m²) of hot mopping asphalt without gravel surfacing.
- (2) Tests of assemblies with such roof covering shall not preclude the field use of other built-up roof coverings.

5.2 Protection and Conditioning of Test Specimen. The test specimen shall be protected during and after fabrication to ensure its quality and condition when tested.

5.2.1 The specimen shall not be tested until close to its full strength, and if it contains moisture, it shall not be tested until the excess moisture has been removed to achieve an air-dry condition in accordance with the requirements of 5.2.2 through 5.2.5.

5.2.2 The testing equipment and sample undergoing the fire test shall be protected from any condition of wind or weather that might lead to abnormal results.

5.2.3 The ambient air temperature at the beginning of the test shall be within the range of 50°F to 90°F (10°C to 32°C).

5.2.4 The velocity of air across the unexposed surface of the sample, measured immediately before the test begins, shall not exceed 4.4 ft/sec (1.3 m/sec) as determined by an anemometer placed at a right angle to the unexposed surface.

5.2.5 If mechanical ventilation is used during the test, an air-stream shall not be directed across the surface of the specimen.

5.2.6* Prior to the fire test, the construction shall be conditioned with the objective of providing a moisture condition in the specimen representative of that likely to exist in similar construction in buildings.

5.2.6.1 For purposes of standardization, the moisture condition shall be considered to be that which would exist at equilibrium as a result of drying in an ambient atmosphere of 50 percent relative humidity at 73°F (23°C).

5.2.6.2 Where it is difficult or impossible to achieve such a condition within a reasonable time, specimens shall be permitted to be tested when the dampest portion of the structure [i.e., the portion at 6 in. (152 mm) depth below the surface of massive constructions] has achieved a moisture content corresponding to drying to equilibrium with air in the range of 50 percent to 75 percent relative humidity at 73°F ± 5°F (23°C ± 3°C).

5.2.6.3 The following also shall apply to the requirements for conditioning of the test specimen:

- (1) In the event that specimens dried in a heated building fail to meet the requirements of Section 5.2 through 5.2.6.2 after a 12-month conditioning period or in the event that the nature of the construction is such that it is evident that drying of the specimen interior is prevented by hermetic sealing, these requirements shall be permitted to be waived.
- (2) The requirement for testing of the specimen only after nearing its full strength shall not be permitted to be waived.

5.2.7 If during the conditioning of the specimen it appears desirable or is necessary to use accelerated drying techniques, it shall be the responsibility of the laboratory conducting the test to avoid procedures that significantly alter the structural or fire endurance characteristics of the specimen, or both, from those produced as the result of drying in accordance with the procedures in 5.2.1.

5.2.8* Within 72 hours prior to the fire test, information on the actual moisture content and distribution within the specimen shall be obtained and included in the test report.