

NFPA®

557

Standard for Determination of Fire Loads for Use in Structural Fire Protection Design

2020



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NFPA® 557

Standard for

Determination of Fire Loads for Use in Structural Fire Protection Design

2020 Edition

This edition of NFPA 557, *Standard for Determination of Fire Loads for Use in Structural Fire Protection Design*, was prepared by the Technical Committee on Hazard and Risk of Contents and Furnishings. It was issued by the Standards Council on April 28, 2019, with an effective date of May 18, 2019, and supersedes all previous editions.

This edition of NFPA 557 was approved as an American National Standard on May 18, 2019.

Origin and Development of NFPA 557

The 2012 edition marked the first edition of NFPA 557, *Standard for Determination of Fire Loads for Use in Structural Fire Protection Design*. This document dates back to 2003, when it was proposed that NFPA create a document to address the need for guidance and standardization in the area of structural fire engineering. The Technical Committee on Hazard and Risk of Contents and Furnishings was assigned the document, and work began shortly thereafter.

NFPA 557 addresses the determination of the fire load and fire load density to be used as the basis for the evaluation and design of the structural fire performance of a building. The purpose of NFPA 557 is to provide standard methods and values for use in the determination of fire loads and fire load densities for design-basis fires. This is done using a risk framework. Two methodologies are detailed in the document: an occupancy-based density method and a survey-based method.

The 2016 edition contained new language that required the evaluation of a fire load to be prepared by an approved person and required the building owner to be responsible for confirming that anticipated fire load densities would not exceed values used for the design. New language in Chapter 4 provided required performance and test criteria for noncombustible and limited-combustible materials. Additional updates to terminology, definitions, and referenced publications were made throughout the document to reflect current industry standards and technology.

The 2020 edition contains updated language for defining a limited-combustible material and adds guidance in the annex regarding fire losses in warehouses. The heat of combustion values were reorganized into a table for ease of use. No technical changes have been made to the values. Reference documents were updated to reflect the most current editions available.

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NFPA 557

Standard for

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2020 Edition

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

Chapter 1 Administration

1.1* Scope. The scope of this standard is the determination of the fire load and fire load density to be used as the basis for the evaluation and design of the structural fire performance of a building.

1.1.1 The determination of a design-basis fire is outside the scope of this standard.

1.1.2* This document is not intended to address facilities for storage of hazardous materials.

1.2 Purpose. The purpose of this standard is to provide standard methods and values for use in the determination of fire loads and fire load densities for design-basis fires, which is done using a risk framework.

1.3 Application. This standard applies to the determination of fire loads and fire load densities based on occupancy.

1.4 Equivalency. Nothing in this standard is intended to prevent the use of methods equivalent or superior in effectiveness and safety over those prescribed by this standard.

1.5 Units and Formulas.

1.5.1 The units of measure in this standard are presented in the International System (SI) of Units.

1.5.2 The values presented for measurements in this standard are expressed with a degree of precision appropriate for practical application and enforcement. It is not intended that the application or enforcement of these values be more precise than the precision expressed.

1.5.3 Where extracted text contains values expressed in only one system of units, the values in the extracted text have been retained without conversion to preserve the values established by the responsible technical committee in the source document.

1.6 Approved Qualifications. The evaluation of the fire load shall be prepared by an approved person.

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. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 70®, *National Electrical Code*®, 2017 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2018 edition.

NFPA 101®, *Life Safety Code*®, 2018 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2018 edition.

2.3 Other Publications.

2.3.1 ASCE Publications. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.

ASCE/SEI 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, 2017.

2.3.2 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959. www.astm.org

ASTM E84, *Test Method for Surface Burning Characteristics of Building Materials*, 2018b.

ASTM E136, *Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2016a.

ASTM E2652, *Test Method for Behavior of Materials in a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2016.

ASTM E2965, *Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, 2017.

2.3.3 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2018.

2.3.4 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 101®, *Life Safety Code*®, 2018 edition.

NFPA 555, *Guide on Methods for Evaluating Potential for Room Flashover*, 2017 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2018 edition.

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* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Shall. Indicates a mandatory requirement.

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

3.2.5 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Alteration. See 3.3.12, Renovation.

3.3.2 Change of Use. A change in the purpose or level of activity within a structure that involves a change in the application of code requirements.

3.3.3 Contents and Furnishings. Any movable objects in a building that normally are secured or otherwise put in place for functional reasons, excluding (1) parts of the internal structure of the building and (2) any items meeting the definition of interior finish. [555, 2017]

3.3.4 Design-Basis Fire. The set of conditions that define the development of a fire and the spread of combustion products throughout a building or portions thereof.

3.3.5 Fire Load. The total energy content of combustible materials in a building, space, or area including furnishing and contents and combustible building elements expressed in MJ.

3.3.5.1* Contents Fire Load. The fire load of all movable or secured contents and furnishings and all occupant possessions within a compartment, including all the items that can be placed into a compartment or taken out of it without causing structural damage, expressed in MJ.

3.3.5.2 Distributed Fire Load. The overall fire load of the compartment, expressed in MJ.

3.3.5.3* Fixed Fire Load. The fire load of all combustible materials used as structural elements or as interior finish or trim (wall, ceiling, and floor) or installed concealed behind walls, floor, or ceiling, expressed in MJ.

3.3.5.4* Localized Fire Load. The fire load at a location within the compartment that is outside the scope of normal variations in the distributed fire load, expressed in MJ.

3.3.6* Fire Load Density. The heat energy, expressed in MJ/m², that could be released per unit floor area of a compartment by the combustion of the contents of the compartment and any combustible part(s) of the building itself.

3.3.7 Fuel Load. The total wood equivalent mass of combustible materials in a building, space, or area, including furnishings and contents and combustible building elements, expressed in kg.

3.3.8* Interior Finish. The exposed surfaces of walls, ceilings, and floors within buildings. [101, 2018]

3.3.9 Material.

3.3.9.1 Limited-Combustible Material. See 4.6.2.

3.3.9.2 Noncombustible Material. See 4.6.1.

3.3.10* Modification. The reconfiguration of any space; the addition or elimination of any door or window; the addition or elimination of load-bearing elements; the reconfiguration or extension of any system; or the installation of any additional equipment. [101, 2018]

3.3.11 Occupancy. The purpose for which a building or other structure, or part thereof, is used or intended to be used. [ASCE/SEI 7:1.2.1]

3.3.12 Renovation. The replacement in kind, strengthening, or upgrading of building elements, materials, equipment, or fixtures that does not result in a reconfiguration of the building or spaces within. [101, 2018]

3.3.13 Repair. The patching, restoration, or painting of materials, elements, equipment, or fixtures for the purpose of maintaining such materials, elements, equipment, or fixtures in good or sound condition. [101, 2018]

3.3.14 Structurally Significant Fire. A fire that grows to a size that poses a threat to the structural elements.

Chapter 4 Design Fundamentals

4.1* Methodology. The methodology developed in this standard shall provide a risk-based design fire load and fire load densities for use in design and evaluation of structural fire performance.

4.2 Fire Load. The fire load for design-basis fires shall be determined by a combination of all of the following:

- (1) Statistical distribution of fire loads in buildings
- (2) Fire initiation frequency
- (3) Effectiveness and reliability of the fire protection features that contribute to fire control in the early stages of the fire

4.3 Statistical Distribution of Fire Load. The statistical distribution of the fire load of the building shall be determined by one of the following:

- (1) Statistical sampling and analysis of the subject or similar buildings, as provided in Chapter 7
- (2) Through the use of suitable occupancy-based means and standard deviation of the fire load distribution, as provided in Chapter 6

4.4 Frequency of Fire Initiations. The frequency of fire initiations in the building shall be determined from national statistical studies of fire incident data.

4.5 Effectiveness of Fire Protection Features.

4.5.1 The effectiveness of fire protection features in controlling fires before the fire becomes structurally significant shall be assessed by all of the following:

- (1) Functional analysis
- (2)* National statistical analysis for the country of the design site

4.5.2 Explanation of Statistics Used. If the statistics used for compliance with 4.5.1 are local or regional, an explanation shall be provided as to why these statistics are applicable for this analysis.

4.6 Combustibility of Materials.

4.6.1* Noncombustible Material.

Δ **4.6.1.1** A material that complies with any of the following shall be considered a noncombustible material:

- (1)* A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.
- (2) A material that is reported as passing ASTM E136, *Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.
- (3) A material that is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Test Method for Behavior of Materials in a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*.

4.6.1.2 Where the term *limited-combustible* is used in this standard, it shall also include the term *noncombustible*.

4.6.2 Limited-Combustible Material. A material shall be considered a limited-combustible material where both the following conditions of 4.6.2(1) and 4.6.2(2), and the conditions of either 4.6.2.1 or 4.6.2.2, are met.

- (1) The material does not comply with the requirements for noncombustible material in accordance with 4.6.1.
- (2) The material, in the form in which it is used, exhibits a potential heat value not exceeding 8141 kJ/kg (3500 Btu/lb) where tested in accordance with NFPA 259. [5000:7.1.4.2]

Δ **4.6.2.1** The material shall have a structural base of a noncombustible material with a surfacing not exceeding a thickness of 3.2 mm (1/8 in.) where the surfacing exhibits a flame spread index not greater than 50 when tested in accordance with ASTM E84, *Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Test for Surface Burning Characteristics of Building Materials*. [5000:7.1.4.2.1]

Δ **4.6.2.2** The material shall be composed of materials that in the form and thickness used, neither exhibit a flame spread index greater than 25 nor evidence of continued progressive combustion when tested in accordance with ASTM E84, *Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Test for Surface Burning Characteristics of Building Materials*, and are of such composition that all surfaces that would be exposed by cutting through the material on any plane would neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723. [5000:7.1.4.2.2]

N **4.6.2.3** Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, *Test for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Combustion Calorimeter*, at an incident heat flux of 75 kW/m² for a 20-minute exposure, and both the following conditions are met:

- (1) The peak heat release rate shall not exceed 150 kW/m² for longer than 10 seconds.
- (2) The total heat released shall not exceed 8 MJ/m². [5000:7.1.4.2.3]

4.6.2.4 Where the term *limited-combustible* is used in this standard, it shall also include the term *noncombustible*. [5000:7.1.4.2.4]

Chapter 5 Development of Fire Loads

5.1 Types of Fire Loads. Fire loads shall be calculated as both localized fire loads and distributed fire loads.

5.1.1* Prior to a change of use or occupancy, renovation, or modification, the building owner shall be responsible for the evaluation of the new fire load.

5.1.2 If there is a change of use or occupancy, and the fire load in the new use or occupancy exceeds the fire load that was originally developed, then the fire resistance of the building shall be analyzed to evaluate if the existing passive fire protection meets the design objectives for the new use or occupancy.

5.2 Defining the Compartment.

5.2.1 The compartment shall be selected as either the entire building or that portion of the building that is bounded by exterior surfaces of the building and by fire-rated boundaries that are capable of containing a fire for the entire duration through burnout.

5.2.2 For areas where there are no fire-rated boundaries, the entire building shall be selected.

5.3 Distributed Fire Loads.

5.3.1 Distributed fire loads shall be determined to reflect the total fire load throughout a compartment.

Table 5.7.1.2 Fraction of Fires That Are Structurally Significant in Office/Business Occupancies

Type of Construction*	No Detection or No Alarm (No Sprinklers)	No Detection or No Alarm (Sprinklers Present)	Detection and Alarm Present (No Sprinklers)	Detection and Alarm Present (Sprinklers Present)
Fire resistive	0.13	0.04	0.07	0.03
Protected, noncombustible	0.15	0.05	0.06	0.03
Unprotected, noncombustible	0.19	0.07	0.10	0.05
Protected, ordinary	0.21	0.03	0.10	0.04
Unprotected, ordinary	0.30	0.11	0.17	0.07
Protected, wood frame	0.30	0.13	0.18	0.08
Unprotected, wood frame	0.37	0.12	0.20	0.07

*For more information on types of construction, see A.5.7.1.2.

5.3.2 Distributed fire loads shall be determined in accordance with Chapter 6 or Chapter 7.

5.4 Localized Fire Loads.

5.4.1 Localized fire loads shall be determined to reflect concentrations of combustible material that have the potential to pose a more severe thermal exposure than the thermal exposure that would result from the uniform fire load.

5.4.2* Combustible materials shall be considered concentrated whenever the mass per unit area of one or more items is a factor of 2.57 greater than the established distributed fire load.

5.4.3 Localized fire loads shall be determined based upon surveys as described in Chapter 7 or upon architectural design data.

5.4.4 The localized fire load determined in accordance with this section shall be subject to the approval of the authority having jurisdiction (AHJ).

5.4.5 Localized fire loads shall be reported by location in the building and shall include the expected value and a measure of the variability of the value (mean and standard deviation).

5.5 Frequency of Structurally Significant Fires.

5.5.1 Methodology.

5.5.1.1 The frequency of structurally significant fires shall be developed by estimating the rate of fires per year relative to the numbers of buildings and to the area of floor space, for buildings of similar occupancy to the building being designed.

5.5.1.2* The frequency of structurally significant fires shall be determined by multiplying the rate of reportable fires per year per floor area by the fraction of fires that are structurally significant in buildings with similar construction and fire protection systems as proposed for the building.

5.5.1.3 The frequency of structurally significant fires, f_{ss} , shall be calculated as the product of the fire frequency, f_f , and the floor area, A_f , as follows:

$$f_{ss} = f_f \times A_f \quad [5.5.1.3]$$

where:

f_{ss} = frequency of structurally significant fires (fires/year)

f_f = fire frequency (fires/m² year)

A_f = floor area (m²)

5.6 Approvals and Limitations.

5.6.1* The limitations on the estimates of the frequency of structurally significant fires along with any limitations of the applicability of the structurally significant fire frequency for a particular building shall be subject to the approval of the AHJ.

5.6.2 The limitations of the applicability on the estimate of the frequency of the structurally significant fire for each particular building or facility shall be addressed within a technical report and provided to the AHJ for review and approval.

5.6.3* The frequency of structurally significant fires shall be developed from national statistics per Section 5.7 and Annex D.

5.6.4 As an alternative to the procedures in Section 5.6, other published data shall be used subject to approval of the applicability of the data by the AHJ.

5.7* Application of the Frequencies of Structurally Significant Fires to Occupancies.

5.7.1* Office/Business Occupancies.

5.7.1.1* For office/business occupancies, the frequency of fires shall be taken as 6 fires per million square meters per year.

5.7.1.2* For office/business occupancies, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.1.1 by the value in Table 5.7.1.2 that corresponds to the construction type and fire protection systems specified for the building.

5.7.2* Religious Properties.

5.7.2.1* For religious properties, the frequency of fires shall be taken as 6 fires per million square meters per year.

5.7.2.2* For religious properties, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.2.1 by the value in Table 5.7.1.2 that corresponds to the construction type and fire protection systems specified for the building.

Table 5.7.2.2 Fraction of Fires That Are Structurally Significant in Religious Properties

Type of Construction	No Detection or No Alarm (No Sprinklers)	Detection and Alarm Present (No Sprinklers)	No Detection or No Alarm (Sprinklers Present)	Detection and Alarm Present (Sprinklers Present)
Fire resistive	0.22	0.06	0	0
Protected, noncombustible	0.16	0.07	0.07	0.03
Unprotected, noncombustible	0.23	0.15	0	0.43
Protected, ordinary	0.24	0.12	0.14	0
Unprotected, ordinary	0.29	0.18	0.22	0.05
Protected, wood frame	0.33	0.17	0.06	0.03
Unprotected, wood frame	0.39	0.20	0.08	0.18

Table 5.7.3.2 Fraction of Fires That Are Structurally Significant in Eating and Drinking Establishments

Type of Construction	No Detection or No Alarm (No Sprinklers)	Detection and Alarm Present (No Sprinklers)	No Detection or No Alarm (Sprinklers Present)	Detection and Alarm Present (Sprinklers Present)
Fire resistive	0.16	0.10	0.05	0.03
Protected, noncombustible	0.16	0.06	0.04	0.04
Unprotected, noncombustible	0.20	0.10	0.08	0.05
Protected, ordinary	0.19	0.11	0.06	0.04
Unprotected, ordinary	0.24	0.14	0.08	0.05
Protected, wood frame	0.22	0.12	0.08	0.05
Unprotected, wood frame	0.29	0.19	0.11	0.07

5.7.3* Eating and Drinking Establishments.

5.7.3.1* For eating and drinking establishments, the frequency of fires shall be taken as 81 fires per million square meters per year.

5.7.3.2* For eating and drinking establishments, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.3.1 by the value in Table 5.7.3.2 that corresponds to the construction type and fire protection systems specified for the building.

5.7.4* Other Public Assembly.

5.7.4.1* For other public assembly buildings, the frequency of fires shall be taken as 10 fires per million square meters per year.

5.7.4.2* For other public assembly buildings, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.4.1 by the value in Table 5.7.4.2 that corresponds to the construction type and fire protection systems specified for the building.

5.7.5* Educational.

5.7.5.1* For educational buildings, the frequency of fires shall be taken as 10 fires per million square meters per year.

5.7.5.2* For educational buildings, the frequency of structurally significant fires shall be determined by multiplying the fire

frequency in 5.7.5.1 by the value in Table 5.7.5.2 that corresponds to the construction type and fire protection systems specified for the building.

5.7.6* Facilities That Care for the Sick.

5.7.6.1* For facilities that care for the sick, the frequency of fires shall be taken as 16 fires per million square meters per year.

5.7.6.2* For facilities that care for the sick, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.6.1 by the value in Table 5.7.6.2 that corresponds to the construction type and fire protection systems specified for the building.

5.7.7* Stores/Mercantile Buildings.

5.7.7.1* For stores/mercantile buildings, the frequency of fires shall be taken as 16 fires per million square meters per year.

5.7.7.2* For stores/mercantile buildings, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.7.1 by the value in Table 5.7.7.2 that corresponds to the construction type and fire protection systems specified for the building.