NFPA® 557

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

2023 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA® 557

Standard for

Determination of Fire Loads for Use in Structural Fire Protection Design

2023 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 March 20, 2022, with an effective date of April 9, 2022, and supersedes all previous editions.

This edition of NFPA 557 was approved as an American National Standard on April 9, 2022.

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 contained updated language for defining a limited-combustible material and added 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 were made to the values. Reference documents were updated to reflect the most current editions available.

The 2023 edition contains guidance on fire load calculations for ignition-resistant materials when the calorific value is unknown. New language provides test requirements for ignition-resistant materials and fire-retardant-treated wood products.

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Committee Scope: This Committee shall have primary responsibility for documents on fire hazard calculation procedures for use by other Committees in writing provisions to control the fire hazards of contents and furnishings. This Committee shall also provide guidance and recommendations to Committees in assessing the fire hazard of contents and furnishings. It shall establish classification and rating systems, request the development and standardization of appropriate fire tests, and identify and encourage necessary research as it relates to the fire hazards of contents and furnishings. It shall act in a liaison capacity between NFPA and the committees of other organizations with respect to the hazard of contents and furnishings.

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Standard for

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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.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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®*, 2023 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2021 edition.

NFPA *101®*, *Life Safety Code®*, 2021 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*, 2021a.

ASTM E136, *Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2019a.

ASTM E2652, *Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2018.

ASTM E2768, *Test Method for Extended Duration Surface Burning Characteristics of Building Materials (30 min Tunnel Test)*, 2011 (2018).

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*®, 2021 edition.
NFPA 555, *Guide on Methods for Evaluating Potential for Room Flashover,* 2017 edition.
NFPA 5000®, *Building Construction and Safety Code*®, 2021 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 phrases "standards development process" or "standards development activities," the term "standards" includes all NFPA standards, including codes, 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/m^2, 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*,** 2021]

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*,** 2021]

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 7-16:**1.2.1]

Δ **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.

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*,** 2021]

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.

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 Assessing Combustibility of Materials Using 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 Assessing Combustibility of Materials Using 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.*

Δ **4.6.2 Limited-Combustible Material.** A material shall be considered a limited-combustible material where one of the following is met:

(1) The conditions of 4.6.2.1 and 4.6.2.2 and the conditions of either 4.6.2.3 or 4.6.2.4 shall be met.
(2) The conditions of 4.6.2.5 shall be met.

[**5000:**7.1.4.2]

N **4.6.2.1** The material does not comply with the requirements for a noncombustible material in accordance with 4.6.1. [**5000:**7.1.4.2.1]

N **4.6.2.2** The material, in the form in which it is used, exhibits a potential heat value not exceeding 8141 kJ/kg (3500 Btu/lb), when tested in accordance with NFPA 259. [**5000:**7.1.4.2.2]

Δ **4.6.2.3** The material shall have a structural base of noncombustible material with a surfacing not exceeding a thickness of 3.2 mm (⅛ 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:**7.1.4.2.3]

Δ **4.6.2.4** The material shall be composed of materials that in the form and thickness used 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, 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:**7.1.4.2.4]

4.6.2.5 Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, *Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, at an incident heat flux of 75 kW/m^2 for a 20-minute exposure, and both the following conditions are met:

(1) The peak heat release rate shall not exceed 150 kW/m^2 for longer than 10 seconds.
(2) The total heat released shall not exceed 8 MJ/m^2.

[**5000:**7.1.4.2.5]

4.6.2.6 Where the term *limited-combustible* is used in this standard, it shall also include the term *noncombustible.* [**5000:**7.1.4.2.6]

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.

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:

[5.5.1.3]

$$f_{ss} = f_f \times A_f$$

where:
f_{ss} = frequency of structurally significant fires (fires/year)
f_f = fire frequency (fires/m^2 year)
A_f = floor area (m^2)

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 5.7.2.2 that corresponds to the construction type and fire protection systems specified for the building.

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.

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

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

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

Δ **Table 5.7.4.2 Fraction of Fires That Are Structurally Significant in Other Public Assembly Buildings**

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	0.13	0.05	0.04	0.02
Protected, noncombustible	0.16	0.06	0.03	0.05
Unprotected, noncombustible	0.20	0.13	0.04	0.06
Protected, ordinary	0.21	0.11	0.04	0.03
Unprotected, ordinary	0.31	0.15	0.05	0.03
Protected, wood frame	0.33	0.18	0.12	0.05
Unprotected, wood frame	0.43	0.22	0.10	0.08

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.

Table 5.7.5.2 Fraction of Fires That Are Structurally Significant in Educational Buildings

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	0.07	0.03	0.04	0.02
Protected, noncombustible	0.07	0.04	0.02	0.03
Unprotected, noncombustible	0.09	0.04	0.01	0.02
Protected, ordinary	0.08	0.04	0.05	0.03
Unprotected, ordinary	0.16	0.08	0.04	0.05
Protected, wood frame	0.18	0.07	0.05	0.02
Unprotected, wood frame	0.30	0.13	0.11	0.03

Table 5.7.6.2 Fraction of Fires That Are Structurally Significant in Facilities That Care for the Sick

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	0.03	0.02	0.02	0.01
Protected, noncombustible	0.03	0.02	0.02	0.01
Unprotected, noncombustible	0.08	0.04	0	0.01
Protected, ordinary	0.10	0.03	0.03	0.02
Unprotected, ordinary	0.17	0.05	0	0.01
Protected, wood frame	0.19	0.07	0.35	0.02
Unprotected, wood frame	0.14	0.14	0	0.01

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.

5.7.8* Places Where People Sleep Other Than Homes.

5.7.8.1* For places where people sleep other than homes, the frequency of fires shall be taken as 43 fires per million square meters per year.

5.7.8.2* For places where people sleep other than homes, the frequency of structurally significant fires shall be determined by multiplying the fire frequency in 5.7.8.1 by the value in Table 5.7.8.2 that corresponds to the construction type and fire protection systems specified for the building.

5.7.9* Warehouse. (Reserved)

Table 5.7.7.2 Fraction of Fires That Are Structurally Significant in Stores/Mercantile Buildings

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	0.18	0.13	0.05	0.04
Protected, noncombustible	0.17	0.10	0.03	0.03
Unprotected, noncombustible	0.25	0.16	0.05	0.05
Protected, ordinary	0.24	0.16	0.07	0.05
Unprotected, ordinary	0.31	0.21	0.09	0.09
Protected, wood frame	0.30	0.19	0.10	0.11
Unprotected, wood frame	0.41	0.28	0.20	0.06

Table 5.7.8.2 Fraction of Fires That Are Structurally Significant in Places Where People Sleep Other Than Homes

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	0.09	0.04	0.04	0.02
Protected, noncombustible	0.11	0.04	0.05	0.02
Unprotected, noncombustible	0.13	0.05	0.03	0.03
Protected, ordinary	0.16	0.09	0.04	0.02
Unprotected, ordinary	0.23	0.12	0.05	0.03
Protected, wood frame	0.21	0.13	0.03	0.03
Unprotected, wood frame	0.32	0.18	0.09	0.03

Chapter 6 Occupancy-Based Fire Load Density

6.1* Fire Load Density.

6.1.1 The average fire load density shall be the sum of the average fixed fire load density and the average contents fire load density, calculated as follows:

[6.1.1]

$$\bar{Q}_f = \bar{Q}_{f,f} + \bar{Q}_{f,c}$$

where:
$\bar{Q}_f$ = average fire load density (MJ/m^2)
$\bar{Q}_{f,f}$ = average fixed fire load density (MJ/m^2)
$\bar{Q}_{f,c}$ = average contents fire load density (MJ/m^2)

6.1.2 The standard deviation of the total fire load density, σ_f, shall be calculated from the standard deviations of the fixed fire load density, $\sigma_{f,f}$, and contents fire load density, $\sigma_{f,c}$, as follows:

[6.1.2]

$$\sigma_f = \sqrt{\left(\sigma_{f,f}^2 + \sigma_{f,c}^2\right)}$$

where:
σ_f = standard deviation of fire load density (MJ/m^2)
$\sigma_{f,f}$ = standard deviation of fixed fire load density (MJ/m^2)
$\sigma_{f,c}$ = standard deviation of contents fire load density (MJ/m^2)

6.1.3* Contents Fire Load Density. For office/business occupancies, the average contents fire load shall be 600 MJ/m^2 floor area and the standard deviation shall be 500 MJ/m^2 floor area.

6.1.4 Fixed Fire Load Density. For buildings of noncombustible construction, the average fixed fire load density shall be 130 MJ/m^2 and the standard deviation shall be 40 MJ/m^2.

6.2 Design Fire Load Density.

6.2.1 The design fire load density shall be determined to achieve the risk performance criteria stated by the applicable code, using the methods described in this section.

6.2.2 Where the applicable code does not provide risk performance criteria for structural fire protection, the risk performance criteria for structural collapse, R_s, shall be no greater than 10^{-6}/yr, unless another value is approved by the AHJ.

6.2.3* Design Fire Load Density Calculation.

6.2.3.1 The design fire load density, Q_f, shall be determined from the frequency of structurally significant fires, f_{ss}, and the risk performance criterion as follows:

[6.2.3.1a]

$$Q_f = \bar{Q}_f - \frac{\sqrt{6}}{\pi}\sigma_f\left(0.577 + \ln(-\ln F)\right)$$

where:
$\bar{Q}_f$ = average fire load (MJ/m^2)
F = risk objective (See 6.2.3.2)

[6.2.3.1b]

$$\sigma_f = \sqrt{\left(\sigma_{f,f}^2 + \sigma_{f,c}^2\right)}$$

where:
σ_f = standard deviation of fire load density (MJ/m^2)
$\sigma_{f,f}$ = standard deviation of fixed fire load density (MJ/m^2)
$\sigma_{f,c}$ = standard deviation of contents fire load density (MJ/m^2)

6.2.3.2 The cumulative probability function required to achieve the risk objective, F, shall be calculated as follows:

[6.2.3.2]

$$F = 1 - R_s / f_{ss}$$

where:
R_s = risk performance criteria for structural collapse (from 6.2.1 and 6.2.2)
f_{ss} = frequency of structurally significant fires (from Section 5.5)

6.2.3.3 This section is applicable to the overall and localized fire load densities.

Chapter 7 Survey Method-Based Fire Load Density

7.1 Fire Load Density The fire load density shall consist of the total fire load divided by the floor area of the compartment.

7.2 Fire Load.

7.2.1 The total fire load shall be calculated in accordance with 7.2.2 and shall include all of the fixed fire load and all of the contents fire load.

7.2.2 The total fire load in a surveyed compartment shall be computed using the following equation:

[7.2.2]

$$Q = \sum k_i \; m_i \; h_{c_i}$$

where:
Q = total fire load in compartment (MJ)
k_i = proportion of content or building component, i, that is combustible
m_i = mass of item, i (kg)
h_{ci} = calorific value of item, i (MJ/kg)

7.2.3* The fire load density in a compartment is the total fire load per square meter of the floor area, Q'', (MJ/m^2), as follows:

[7.2.3]

$$Q'' = Q / A_f$$

where:
Q'' = total fire load per m^2 of floor area
Q = total fire load in compartment
A_f = floor area of fire compartment (m^2)

7.3* Heats of Combustion.

7.3.1* The fire load for an item shall be determined by multiplying the mass by the calorific value (heat of combustion) for the item.

7.3.2* If the calorific value of the item is not known, the fire load shall be determined by multiplying the mass of the item by the heat of combustion in Table 7.3.2.

N **7.3.2.1** A wood product shall be acceptable as a fire retardant–treated wood product for this standard if it has been impregnated with chemicals and, when tested in accordance with ASTM E2768, *Test Method for Extended Duration Surface Burning Characteristics of Building Materials (30 min Tunnel Test)*, it exhibits a flame spread index not exceeding 25 (during the first 10 minutes of the test) and a flame front that does not progress more than 3.2 m (10.5 ft) beyond the centerline of the burner at any time during the test, on both the front and back faces.

N **7.3.2.2** A product shall be considered an ignition-resistant material for this standard if it does not have a coating or other exterior protective layer and, when tested in accordance with ASTM E2768, it exhibits a flame spread index not exceeding 25 (during the first 10 minutes of the test) and a flame front that does not progress more than 3.2 m (10.5 ft) beyond the centerline of the burner at any time during the test, on both the front and back faces.

7.3.3 If items are derived from a known combination of materials, the fire load for that item shall be determined by multiplying the heat of combustion of the individual materials by their corresponding mass.

7.4 Methodology and Limitations.

7.4.1* The fire load survey shall be conducted by either the weighing technique or the inventory technique, or a combination of the two.

7.4.2* Sample Size Determination.

7.4.2.1 If fire loads are determined by conducting a survey, diverse compartments shall be surveyed and a confidence interval shall be constructed.

7.4.2.2 If the results of the fire load survey will be applied to multiple buildings, then surveys shall be conducted in more than one building.

7.4.3 The individual reports shall be provided for the surveys for fixed and contents fire loads.

7.4.4 For design purposes, confidence intervals of no less than 99 percent shall be used.

7.4.5 Results of the fire load survey reported shall include the mean, standard deviation, and a cumulative probability distribution for the energy content per unit area.

7.4.6 The results from a fire load survey shall only be applied to the building in which it was conducted or to similar buildings.

7.4.7 The value(s) used for mass densities shall be subject to the approval of the AHJ.

7.4.8 The fire load determined in accordance with this section shall be subject to the approval of the AHJ.

Δ **Table 7.3.2 Heat of Combustion**

Material	Heat of Combustion
Unknown or not listed below	40 MJ/kg
Cellulosic materials without a wood structure	17 MJ/kg
Products that have complied with the fire tests required by NFPA 90A or the applicable mechanical code to be used exposed in plenums	15 MJ/kg
Upholstered furniture or mattresses that have complied with the fire tests required for such products according to Chapter 10 of NFPA *101* or by the applicable fire code and have done so without the use of barriers	15 MJ/kg
Electrical or optical fiber wires and cables that have complied with the fire tests required for use in risers (vertical runs in a shaft or from floor to floor) or plenums (ducts, plenums, and other spaces used for environmental air) as required by *NFPA 70*	15 MJ/kg
Wood products that have complied with the requirements of the applicable building code or fire code for classification as fire retardant–treated wood products based on testing as required in 7.3.2.1	10 MJ/kg
Materials or products that have complied with the requirements of limited-combustible materials in accordance with NFPA *101*	8.141 MJ/kg
Materials or products that have complied with the requirements of ignition-resistant materials based on testing as required in 7.3.2.2	20 MJ/kg

Chapter 8 Documentation, Inspection, and Maintenance

8.1 Documented Fire Load.

8.1.1 The design basis for the fire load determined shall be documented in a report that is maintained by the building owner and provided to the AHJ.

8.1.2 The building owner shall be responsible for confirming that the anticipated fire load densities will not exceed the values used for the design as documented in Section 8.1.

8.2 Change in Occupancy.

8.2.1 If there is a change in occupancy, alteration, or renovation, and the fire load in the new occupancy or portion of the building that has been altered or renovated exceeds the fire load that was originally developed, then the fire resistance of the building shall be analyzed to evaluate if the existing fire protection meets the design objectives for the new occupancy or the portion of the building that has been altered or renovated.

8.2.2 If the objectives are no longer met, then modifications to the existing fire protection shall be made as necessary so that the building meets its fire resistance objectives.

8.3 Repairs. Repairs shall not require reanalysis.

8.4 Formal Review. A formal review of the fire load shall be undertaken, documented, and provided to the AHJ at least once every 5 years.

Annex A Explanatory Material

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

A.1.1 This standard is a companion to SFPE S.01, *Engineering Standard on Calculating Fire Exposures to Structures*, and SFPE S.02, *Engineering Standard on Calculation Methods to Predict the Thermal Performance of Structural and Fire Resistive Assemblies.* These standards are used in conjunction with ASCE/SEI 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, and other performance-based design documents.

A.1.1.2 Examples of hazardous materials include combustible dusts, flammable and combustible liquids, flammable solids, oxidizers, and oxidizer-containing waste. Information on such occupancies is contained in NFPA 400.

Δ **A.3.2.1 Approved.** The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the "authority having jurisdiction" may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The "authority having jurisdiction" may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA standards in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.3.5.1 Contents Fire Load. Examples of items in this category are furniture (both movable and secured in place by the occupant), furnishings, appliances (including computers, television sets, and portable lighting), clothing, books and papers, pictures, telephones, rubbish bins, and personal effects. A limited quantity of small movable items that provide negligible contributions to total heat release can generally be ignored.

A.3.3.5.3 Fixed Fire Load. Examples of items in this category are built-in structural elements; built-in closets or cupboards; doors and their frames; windows and their sills; wall, ceiling; and floor linings; electrical and optical fiber wiring (for power or data); piping and tubing (including drain, waste, sprinkler, and pneumatic ones); insulation; and built-in appliances. Small fixed items that provide negligible contributions to total heat release, such as wall switches or other items with low mass can generally be ignored.

A.3.3.5.4 Localized Fire Load. The localized fire load may pose a more severe thermal exposure to individual structural elements than the distributed fire load.

A.3.3.6 Fire Load Density. The higher the value of the fire load density, the greater the potential fire severity and damage, as the duration of the burning period of the fire is proportional to the fire load.

A.3.3.8 Interior Finish. The term *interior finish* includes interior wall and ceiling finish and interior floor finish. With respect to interior wall and ceiling finish, this means the exposed interior surfaces of buildings including, but not limited to, fixed or movable walls and partitions, columns, and ceilings. With respect to interior floor finish, this means the exposed floor surfaces of buildings, including coverings that might be applied over a normal-finished floor or stairs, including risers. Furnishings, which in some cases are secured in place for functional reasons, should not be considered as interior finish. [**555**, 2017]

A.3.3.10 Modification. Modification does not include repair or replacement of interior finishes. [***101*****,** 2021]

A.4.1 The fire load and fire load density determined by application of this standard can be used together with a design basis fire for the determination of the fire exposure to a structure.

A.4.5.1(2) The nation for which the statistics are being used should be the same nation for which the building practices are being considered. In the absence of national statistics, the statistics from other comparable countries may be useful.

A.4.6.1 The provisions of 4.6.1 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials.

A.4.6.1.1(1) Examples of such materials include steel, concrete, masonry, and glass.

A.5.1.1 When selecting a fire load density for a building or other structure, the building owner should consider the possibility of later changes in occupancy or use, which could result in greater fire loads than originally contemplated. In the event that the fire load increases beyond that contemplated during the design, reanalysis must be performed, and it may be necessary to modify the fire protection applied to the building.

A.5.4.2 The factor of 2.57 was selected based on the *Z* value used in confidence intervals. A *Z* value of 2.57 approximately corresponds to a confidence interval of 99 percent (based upon a normally distributed variable). Annex C provides a means to determine the safety factor for 99 percent confidence level.

A.5.5.1.2 Fires that extend beyond the room of origin are considered to be structurally significant because they represent compartment fires that flash over and spread to additional spaces. Sprinklers or other automatic extinguishing equipment, automatic detection equipment, and construction will influence the likelihood of a fire extending beyond the room of origin. Fires that extend beyond the room of origin are considered to present a significant challenge to the structure. Therefore, statistics or data for buildings with fire protection systems or construction methods similar to those proposed may be used to determine the structurally significant fire frequency. The structurally significant fire frequency for a given building type and set of fire protection systems and construction methods may be greater than or less than the structurally significant fire frequency for the building type with data for all combinations of fire protection systems and construction methods aggregated. See A.5.7.2.1 through A.5.7.8.1 for more information.

A.5.6.1 Limitations may arise from several sources. Fire frequencies are culturally influenced or determined. The fraction of fires reported can vary with country and jurisdiction, depending upon local customs and regulations. Actual fire frequencies can also vary by country based upon cultural differences and differences in regulations concerning potential ignition sources.

A.5.6.3 The tables used for calculating the factors take into account the type of construction and the presence or absence of detection and alarm systems and of sprinklers.

A.5.7 The occupancies represented in this section and in Annex D may not correlate with the occupancy classifications typically used in current codes and standards. This data is collected from the National Fire Incident Reporting System (NFIRS).

A.5.7.1 For more information, see Annex D.

A.5.7.1.1 The fire frequency of 6 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.8 of Annex D.

A.5.7.1.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant. The data in Table 5.7.1.2 correspond to the analysis provided in Section D.8 of Annex D for office/business occupancies.

The types of construction and property use (e.g., office/business occupancies) indicated in Table 5.7.1.2 are based upon the National Fire Incident Reporting System (NFIRS) incident form. The definitions from the form are extracted as follows (see also www.usfa.fema.gov/downloads/pdf/nfirs/nfirs-1.pdf):

(1) Construction types as follows. Table A.5.7.1.2 relates the types of construction used in Section 5.7 to the types of construction referenced in NFPA 220.

  (a) **Fire resistive.** A totally noncombustible building in which no structural steel is exposed and all vertical openings are protected with approved doors. The fire-resistant covering of the steel is typically very heavy: poured concrete, brick, concrete block, or similar material.
  (b) **Protected, noncombustible.** A totally noncombustible building in which no structural steel is exposed. All vertical openings are protected by approved doors. The fire-resistant covering of the steel is typically light: gypsum board, sprayed fire-resistive covering, rated ceilings, and similar materials.
  (c) **Unprotected, noncombustible.** A totally noncombustible building in which the structural steel is exposed to the effects of fire.
  (d) **Protected, ordinary.** The load-bearing walls are masonry. Columns are protected by a fire-resistive coating. The underside of all wood floor and roof decks is protected by a fire-resistive coating.
  (e) **Unprotected, ordinary.** The load-bearing walls are masonry. Columns, wood floor, and roof decks are exposed and unprotected from fire.
  (f) **Protected, wood frame.** Walls, floors, and roof structure are wood framing. The interior wall and ceiling surfaces of habitable spaces are protected by a fire-resistive covering. A brick-veneer building falls in this category because the wall structure is wood framed. But for any wood frame building, if the basement does not have a fire-resistive ceiling protecting the underside of the first floor, the building should be classified in the "unprotected wood frame" category.
  (g) **Unprotected, wood frame.** Walls, floors, and roof structure are wood framing. There is no fire-resistive covering protecting the wood frame. A typical residential garage would fall in this category.

(2) Property Use as follows:

  (a) **Store office property.** Store properties include all markets and other areas, buildings, or structures for the display, sale, repair, or service of merchandise, new or used, purchased or rented. Mercantile or store properties generally have a capacity for a large number of people and usually have a display and sales area that is large in relation to the storage area.
  (b) **Public assembly property (religious properties, eating and drinking establishments, other public assembly).** Places for the congregation or gathering of people for amusement, recreation, social, religious, patriotic, civic, travel, and similar purposes are known as public assembly properties. Such properties are characterized by the presence or

potential presence of crowds, with attendant panic hazard in case of fire or other emergency. They are generally open to the public, or may, on occasions, be open to the public. The occupants are present voluntarily and are not ordinarily subject to discipline or control. They are generally able-bodied persons, whose presence is transient in character, and who do not intend to sleep on the premises.

(c) **Educational property.** Educational properties are those used for the gathering of groups of persons for purposes of instruction such as schools, colleges, universities, and academies. Educational properties are distinguished from public assembly properties in that the same occupants are present regularly, and they are subject to discipline and control. Included are part-day nursery schools, kindergartens, and other schools whose primary purpose is education.

(d) **Institutional property (facilities that care for the sick).** Institutional properties are those used for purposes such as medical or other treatment or care of persons suffering from physical or mental illness, disease, or infirmity; for the care of infants, convalescents, or aged persons; and for penal or corrective purposes. Institutional buildings ordinarily provide sleeping facilities for the occupants.

(e) **Residential property (places where people sleep other than homes).** A residential property is one in which sleeping accommodations are provided for normal living purposes, and includes all buildings designated to provide sleeping accommodations except those classified under Institutional (major division d). Subdivisions of residential property used in this section are separated according to potential life hazard. Popular names and legal definitions may be different from those given here. The categories here, however, are significant from a fire and life protection standpoint.

A.5.7.2 For more information, see Annex D.

A.5.7.2.1 The fire frequency of 6 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.2.

A.5.7.2.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

Table A.5.7.1.2 Comparison of Types of Construction Used in NFPA 557 and NFPA 220

Type of Construction per NFPA 557	Type of Construction per NFPA 220
Fire resistive	Type I
Protected, noncombustible	Type II (222) or Type II (111)
Unprotected, noncombustible	Type II (000)
Protected, ordinary	Type III (211)
Unprotected, ordinary	Type III (200)
Protected, wood frame	Type V (111)
Unprotected, wood frame	Type V (000)

The data in Table 5.7.2.2 correspond to the analysis provided in Section D.2 for religious properties.

See also A.5.7.1.2.

A.5.7.3 For more information, see Annex D.

A.5.7.3.1 The fire frequency of 81 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.3.

A.5.7.3.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

The data in Table 5.7.3.2 correspond to the analysis provided in Section D.3 for eating and drinking establishments.

See also A.5.7.1.2.

A.5.7.4 For more information, see Annex D.

A.5.7.4.1 The fire frequency of 10 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.4.

A.5.7.4.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

The data in Table 5.7.4.2 correspond to the analysis provided in Section D.4 for other public assembly buildings.

See also A.5.7.1.2.

A.5.7.5 For more information, see Annex D.

A.5.7.5.1 The fire frequency of 10 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.5.

A.5.7.5.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

The data in Table 5.7.5.2 correspond to the analysis provided in Section D.5 for educational buildings.

See also A.5.7.1.2.

A.5.7.6 For more information, see Annex D.

A.5.7.6.1 The fire frequency of 16 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.6.

A.5.7.6.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

The data in Table 5.7.6.2 correspond to the analysis provided in Section D.6 for facilities that care for the sick.

See also A.5.7.1.2.

A.5.7.7 For more information, see Annex D.

A.5.7.7.1 The fire frequency of 16 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.7.

A.5.7.7.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

The data in Table 5.7.7.2 correspond to the analysis provided in Section D.7 for stores/mercantile buildings.

See also A.5.7.1.2.

A.5.7.8 For more information, see Annex D.

A.5.7.8.1 The fire frequency of 43 fires per million square meters per year represents the frequency of fires that are reported. A fraction of the fires that start will extend beyond the room of origin. The basis for this fire frequency is provided in Section D.9.

A.5.7.8.2 These values were determined from U.S. National Fire Statistics using spread beyond the compartment of origin as a surrogate for structurally significant.

The data in Table 5.7.8.2 correspond to the analysis provided in Section D.9 for places where people sleep other than homes.

See also A.5.7.1.2.

A.5.7.9 A study of fire losses that occurred in one-story warehouses between 2012 and 2016 was conducted by a large, highly protected risk (HPR) property insurer. There were 285 fires recorded within this 5-year period; however, not all desired information was available for all recorded losses.

There were 78 losses where the area of the warehouse involved was known. The total area was 1,071,148 m^2 (11,536,260 ft^2) and the average area was 13,733 m^2 (147,901 ft^2).

There was information available regarding the presence of detection, alarms, and sprinklers in 241 of the losses. The breakdown is noted in Table A.5.7.9(a). Sprinklers are noted to be provided only if they were in the area of fire origin.

There were 65 fire losses where information was available regarding the type of construction. The breakdown is noted in Table A.5.7.9(b). There was no data available for the other three types of construction noted in Section 5.7. Many warehouses are constructed of either metal walls and roofs (unprotected, noncombustible), or masonry walls and metal roofs (unprotected, ordinary). In the United States, warehouse construction that uses a fire-resistive rating for structural framing is not common.

Table A.5.7.9(a) Number of Fires Based on Presence of Detection, Alarms, and Sprinklers

Protection Type	Number of Losses	Percent of Losses Where Information Was Available
No detection, alarms, or sprinklers	154	63.90
No detection or alarms, sprinklers provided	78	32.37
Detection and alarms provided, no sprinklers provided	5	2.07
Detection, alarms, and sprinklers provided	4	1.66

Table A.5.7.9(b) Number of Fires Based on Type of Construction

Type of Construction	Number of Losses	Percent of Losses Where Information Was Available
Unprotected, noncombustible	28	43.08
Unprotected, ordinary	27	41.54
Unprotected, wood frame	6	9.23
Fire resistive	4	6.15

A.6.1 See Annex B for derivation of the values used in this section.

A.6.1.3 See Culver, "Survey results for fire loads and live loads in office buildings."

A.6.2.3 The design fire load density equations are based on a Gumbel distribution (Type I distribution of largest values) for fire loads. This distribution is widely used for gravity loads and has been verified for fire loads by Korpela and Keski-Rahkonen, "Fire Loads in Office Buildings."

A.7.2.3 Note that some fire load data sources report the fire load densities based upon the compartment bounding surface area rather than the floor area. Care is required to understand the basis of any values in the literature.

A.7.3 The values of 15 MJ/kg and 40 MJ/kg were selected as bounding values for cellulosic materials and plastics, respectively. These values were selected based on effective (sometimes referred to as "chemical") heats of combustion as published in Tewarson, "Generation of Heat and Gaseous, Liquid, and Solid Products in Fires."

A.7.3.1 Data on heat of combustion for selected fuels can be found in Appendix 3 of the *SFPE Handbook of Fire Protection Engineering*.

Δ **A.7.3.2** NFPA 90A requires that the following materials or products exposed to the airflow in plenums comply with the indicated fire tests.

Electrical wires and cables and optical fiber cables must be listed as having a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262.

Pneumatic tubing for control systems must be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 1820, *Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics.*

Nonmetallic fire sprinkler piping must be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 1887, *Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics.*

Optical fiber and communication raceways must be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 2024, *Cable Routing Assemblies and Communications Raceways*.

Loudspeakers, recessed lighting fixtures, and other electrical equipment with combustible enclosures, including their assemblies and accessories, cable ties, and other discrete products, must be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a peak heat release rate of 100 kW or less when tested in accordance with UL 2043, *Fire Test for Heat and Visible Smoke Release for Discrete Products and their Accessories Installed in Air-Handling Spaces.*

Insulation materials and many other products must comply with a flame spread index of 25 or less and a smoke developed index of 50 or less when tested in accordance with ASTM E84, *Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Test Method for Surface Burning Characteristics of Building Materials.*

Chapter 10 of NFPA *101* requires that upholstered furniture items in nonsprinklered facilities comply with a peak heat release rate of no more than 80 kW and a total heat release of no more than 25 MJ during the first 10 minutes when tested in accordance with ASTM E1537, *Test Method for Fire Testing of Upholstered Furniture.* Chapter 10 of NFPA *101* also requires that mattresses in nonsprinklered facilities comply with a peak heat release rate of no more than 100 kW and a total heat release of no more than 25 MJ during the first 10 minutes when tested in accordance with ASTM E1590, *Test Method for Fire Testing of Mattresses.* It is possible to comply with both tests by using barriers enclosing the padding or filling materials; in such cases, the effective heat of combustion will be that of the traditional filling material.

NFPA 70 requires that electrical or optical fiber wires and cables to be used in risers (vertical runs in a shaft or from floor to floor) comply with the requirements of UL 1666, *Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts*; be capable of preventing the carrying of fire from floor to floor; and that wires or cables to be used in plenums (ducts, plenums, and other spaces used for environmental air) comply with the requirements associated with NFPA 262.

Fire retardant–treated wood products must exhibit a flame spread index not exceeding 25 when tested in accordance with ASTM E84 or UL 723 for 10 minutes and have a flame front that does not progress more than 3.2 m (10.5 ft) beyond the centerline of the burner at any time during the test. In 2011, a test (30-minute tunnel test) was developed and documented in ASTM E2768, *Test Method for Extended Duration Surface Burning Characteristics of Building Materials (30 min Tunnel Test)*, which standardized the way in which the 30-min ASTM E84 test is to be conducted. In order for a wood material to be designated as fire retardant–treated wood, it would have to comply with the requirements above when tested using ASTM E2768 on the front and back, and it must be impregnated, and not simply coated, with chemicals.

Materials that comply with the requirements of limited-combustible materials must exhibit a potential heat not exceeding 8.141 MJ/kg when tested in accordance with NFPA 259.

Wildland urban interface codes describe ignition-resistant materials, which are those materials that comply with the same requirements as fire retardant–treated wood products, in terms of having to be tested in accordance with ASTM E2768 (the 30-min ASTM E84 test), exhibiting a flame spread index not exceeding 25 (during the first 10 minutes of the test), and having a flame front that does not progress more than 3.2 m (10.5 ft) beyond the centerline of the burner at any time during the 30-minute test. If the material complies with these requirements on its front and back faces (meaning that it does not meet the requirements for a coating or a protective layer), the material must be considered to exhibit a heat of combustion much lower than that of plastic materials.

A.7.4.1 The weighing technique and the inventory technique are discussed in Annex C. The Fire Protection Research Foundation has completed a study titled “Digitized Fuel Load Survey Methodology Using Machine Vision,” which discusses additional methods for surveying fuel loads in buildings.

A.7.4.2 To construct a confidence interval, the sample mean, $\bar{x}$, is calculated by averaging the results from each of the compartments surveyed. Similarly, the sample standard deviation can be calculated as follows:

[A.7.4.2a]

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}{N}}$$

where:
σ = standard deviation
x_i = fire load from i^{th} sample
$\bar{x}$ = average of all fire load samples
N = number of fire load samples

The confidence interval can then be calculated as follows:

[A.7.4.2b]

$$\bar{x} \pm z\frac{\sigma}{\sqrt{N}}$$

where:
z = confidence interval

For a 99 percent confidence interval, z = 2.57. It should be noted that the size of the confidence interval may decrease if the sample size is increased due to the presence of the square root of the sample size in the denominator. However, if the sample has significant variability, the size of the confidence interval may not decrease below a limit value.

Annex B Summary of Occupancy Based Fuel and Fire Load Survey Data

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

Δ **B.1** The fire load densities in Chapter 6 were developed by identifying and assimilating fuel and fire load data from a number of sources, including the following:

(1) Ingberg et al., "Combustible Contents in Buildings"
(2) Caro and Milke, "A Survey of Fuel Loads in Contemporary Office Buildings"
(3) Baldwin et al., "Survey of Fire Loads in Modern Office Buildings — Some Preliminary Results"
(4) Green, "A Survey of Fire Loads in Hackney Hospital"
(5) "Building Materials and Structures — Fire Resistance Classifications of Building Constructions" (This paper contains the same data as the Ingberg paper.)
(6) Kumar and Rao, "Fire Loads in Office Buildings"
(7) McDonald Barnett Partners, "Pilot Fire Load Survey"
(8) Lee and Parker, "Fire Buildup in Shipboard Compartments – Characterization of Some Vulnerable Spaces and the Status of Prediction Analysis" (Data from this survey were not used since they were based on shipboard compartments.)
(9) Korpela and Keski-Rahkonen, "Fire Loads in Office Buildings"
(10) Culver and Kushner, "Program for Survey of Fire Loads and Live Loads in Office Buildings"
(11) Culver, "Survey results for fire loads and live loads in office buildings"
(12) Thauvoye, Zhao, Klein, and Fontana, "Fire Load Survey and Statistical Analysis"

There was a tremendous amount of variability among the fuel or fire loads published in the surveys cited. The reason for this variability appears to be that within a typical occupancy classification (e.g., business) there are a number of different types of usage among spaces. (e.g., general office, storage, files, etc.).

Culver explored the effect of a number of factors affecting the fuel load in office buildings, including room size, room use, building location (geographic), building age, building height, and government vs. private occupancy. While all of these factors have some effect on fuel loads, Culver found that the use of the room had by far the greatest influence on fuel load.

With the exception of the Ingberg paper, none of the other papers reported space usage as accurately as the Culver report. The Caro report stated that the spaces surveyed were offices, although further investigation has revealed that what was reported as an "office" was, in at least one instance, a cubicle (this was determined through discussions with one of the people whose "office" was surveyed). The mass per unit area of a cubicle is not expected to be representative of the mass per unit floor area of office space, so the Caro findings were not used in developing the fire loads in Chapter 6.

Additionally, while the Ingberg report was more specific than others in terms of space usage, the surveys that were used to generate the data were conducted from 1928 to 1940. One paper on fire loads in India (Kumar and Rao) suggests that between the 1970s and the 1990s, an increased use of steel furniture reduced office fire loads, so the Ingberg data is not likely representative of current fire loads. Therefore, it was not used in developing the fire loads in Chapter 6.

It is also noteworthy that some surveys only included the contents fuel or fire load, while others also included fixed items as well. Some surveys "derated" combustible items that were stored in metal cabinets, while others did not. (The logic behind "derating" items stored in metal cabinets is that they would not be expected to burn as efficiently as items that are not stored in noncombustible cabinets.) Both total fuel loads and derated fuel loads were published in Chapter 6.

Culver published fire load data in units of mass per unit area. Kumar found that 99 percent of the fire load was cellulosic. Given that the precision in this figure is likely greater than the precision in the fuel load values, it is reasonable to round this up to 100 percent. Therefore, conversion between mass and energy is accomplished by using an effective heat of combustion for wood. A value of 15 MJ/kg was used. This value represents an upper limit for reported values of effective heats of combustion for wood-based products as published in Tewarson, "Generation of Heat and Gaseous, Liquid, and Solid Products in Fires." Again, the precision in this value is greater than the precision in the estimates of fuel load.

Live loads in buildings are expected to vary in a similar manner as fuel or fire loads. Indeed, Culver found this to be the case. This is handled in ASCE/SEI 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (the standard that specifies the structural loads that are used to design buildings), by specifying a value that is seldom expected to be exceeded.

The contents fire load densities in Chapter 6 were developed by determining a mean and standard deviation for all of the office fuel load data that was published by Culver. The mean fuel load density was 38.2 kg/m^2 and the standard deviation was 32.8 kg/m^2.

The fixed fire loads were handled in a similar manner; however, Culver found that the fixed fuel load did not vary appreciably with room use. A stronger influence was found to be whether the room surveyed was in a government or private building, with fixed fire loads in private buildings being approximately 50 percent higher than those in government buildings.

Annex C Guidance for Fuel or Fire Load Surveys (Special Facility and Occupancy Based)

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

C.1 General. To simplify the fire load estimation, surveys conducted in the past have made the following assumptions:

(1) Combustible materials are uniformly distributed throughout the building.
(2) All combustible material in the compartment would be involved in a fire.
(3) All combustible material in the fire compartment would undergo total combustion during a fire.

Determining fuel loads in a building requires measuring the mass of all the different types of combustibles and their calorific values. The mass of an item in a compartment can be determined by weighing it (weighing technique) or by determining its volume and identifying its density (inventory technique). The direct-weighing method should be used for items that can easily be weighed, such as toys and books; the inventory method may be used for heavy items that cannot be weighed, such as heavy furniture and built-in shelves. In most cases, a combination of the weighing and inventory methods is used, in which some common items could be pre-weighed, and then the surveyor notes their inventory. To ensure a high quality of the survey data and to avoid inconsistencies that might occur when different individuals complete the survey forms, it is preferable that the survey is conducted by trained individuals who appreciate the importance of the data collected.

C.2 Survey Form. A standard survey form is useful to facilitate the survey process and to ensure that data is collected in a systematic and consistent fashion for all buildings. The survey can be divided into the following five sections:

(1) Building identification and date of investigation
(2) Type of establishment
(3) Compartment dimensions
(4) Fixed fire loads (this section contains information regarding building construction, weight, and type of lining materials)
(5) Movable fire loads

C.3 Survey Process. To facilitate the survey process, it is recommended that the surveyor follow a similar procedure for all buildings. First, the building name and address are recorded, as well as the type of establishment and date of the investigation. Second, the dimensions of the room(s) are measured and the types of wall, floor, and ceiling lining materials are determined and noted in the fixed fire load section of the survey form. The third step identifies and classifies all contents in each compartment. Items that could be weighed are weighed to determine their mass; the materials that the item is made of are determined and recorded. For items consisting of more than one material type, the percentage of each type is determined and quantified. The mass of items that cannot be weighed, such as heavy furniture and built-in shelving units, is determined by measuring their volume and using the density of the material to calculate their mass.

C.4 Survey Results and Analysis. The data collected is analyzed to determine the total fire load in each building compartment, the fire load densities (MJ/m^2), and the contribution of different materials (wood, plastics, textiles, food, etc.) to the total fire load and to the fire load densities.

If the results of the fire load survey are to be applied to multiple buildings, it is important to collect data for a number of similar buildings to ensure that the survey results are valid. Sample sizes (number of compartments surveyed) will vary depending on the variation of values. In some cases, where variations are large, it may be necessary to identify parameters that may affect fire load densities. For example, it was found in some earlier surveys that fire load densities decreased with increasing the area of a building. In such cases, it is preferable to group buildings into categories based on area and to determine fire load densities for each group.

An important component of the survey is to determine the target population and the sample required. The first is deciding the type of buildings that will be surveyed, such as residential buildings, commercial buildings, shopping centers, or industrial buildings. In determining the target population, it is critical to identify any subgroups that may yield different results. For example, if dealing with residential buildings, it is important to differentiate between apartment buildings and houses, as the fire loads may be different.

The second important decision is to determine how many rooms/buildings to use in the survey. The sample size depends on time available, budget, and necessary degree of precision. The following equation can be used to determine a sample size (number of rooms to be surveyed):

[C.4]

$$n = \left(\frac{Z \times \sigma}{\bar{x}} \right)^2$$

where:
Z = Z-value (e.g., 2.57 for 99 percent confidence level)
σ = standard deviation
$\bar{x}$ = sample mean

The standard deviation could be evaluated from a small sample and then used to find the necessary sample size. The larger the sample, the surer one can be that their answers truly reflect the population.

In selecting a sample for the survey, care should be taken to choose a sample that is representative of the population. For example, if one is interested in surveying houses, they should ensure that their sample includes houses of all sizes and price range. If one chooses houses in affluent neighborhoods, they may not have the same fire load as houses in poorer areas.

Annex D Analyses of Structurally Significant Fires in Buildings with Selected Characteristics

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

D.1 These analyses first provide estimates of the rate of fires (per year) relative to numbers of buildings and square feet of floor space, for each of eight property use groups.

Floor space survey data include only buildings with at least 1000 ft^2 (93 m^2) and use property use groupings that may differ from those used for fire data. Details on inclusion and exclusion are provided where available.

Next in each section is the percentage of fires with extent of flame beyond, respectively, the room of origin and the floor of origin. The latter is more likely to be a structurally significant fire than the former. Many properties in every category are not high-rise and may be only one story tall.

Percentages are provided for all fires, for fires in buildings with sprinklers or other automatic extinguishing equipment, for fires in buildings with automatic detection equipment, and for seven types of construction, excluding only heavy timber, for which fires are few and mis-codings appear to be a high proportion of the total.

Four technical papers from Finland and one from Sweden dealing with the same technical issues have also been reviewed. Three papers limited themselves to derivations and model-building for mathematical methods of estimating useful parameters on these subjects. Two papers included actual data from Finland, one for 1996–1999 and one for 1996–2001. The following is a comparison of the categories used in those latter two studies and the categories used in this analysis labeled U.S. in Table D.1.

In each section, Finnish data is provided and discussed.

The Finnish data include figures for industrial buildings (where there is no floor space data in the United States) and warehouses (where there is some floor space data from U.S. sources, but isolating the corresponding storage properties was deemed too speculative and sensitive for this analysis).

D.2 Religious Properties. Specific property use 130–139 includes churches, synagogues, mosques, religious education facilities, and funeral parlors. There is no Finnish data broken down to this level. For data on religious property fires, see Table D.2(a) and Table D.2(b).

D.3 Eating and Drinking Establishments. Specific property use 160–169 includes restaurants, cafeterias, nightclubs, and taverns. Floor space survey data are for food service establishments. There is no Finnish data broken down to this level. For data on eating and drinking establishments, see Table D.3(a) and Table D.3(b).

D.4 Other Public Assemblies. Specific property use 100–199 excluding 130–139 and 160–169 includes exhibition halls, arenas, stadiums, ballrooms, gymnasiums, bowling alleys, ice and roller rinks, swimming facilities, city and country clubs, libraries, museums, court rooms, passenger terminals, and theaters. Floor space survey data are from a category called public assembly that excludes the separate categories of religious properties and food service facilities.

The Finnish data could exclude passenger terminals and could include religious properties and/or eating and drinking establishments. Their data on fires need to be converted from total fires for a multi-year period to average fires per year. Having done so, their rates of fires per million square feet were 0.35 for 1996–1999 and 0.52 for 1996–2001. However, one out of seven buildings had unknown square feet, so it is possible these figures should be reduced by one-seventh. Either way, they are *lower* than the figures related to other public assembly for the United States. If the three public assembly categories are combined, the U.S. figure for all public assembly would be 1.9, even higher than the Finnish figures. Their data on fires per thousand buildings showed 3.3 for 1996–2001 (no such data shown for 1996–1999). This is much *lower* than any comparable U.S. figures. For data on other public assemblies, see Table D.4(a) and Table D.4(b).

Table D.1 Comparison of Analyses of Structurally Significant Fires

Occupancy	U.S. Research	Finland Research
Public assembly	Analysis divided into religious properties, eating and drinking establishments, and other public assembly, including passenger terminals.	Analysis provided for “assembly buildings.” Passenger terminals may be in a second category, whose name includes the word “transport.”
Educational	Analysis provided for all educational properties.	Analysis provided for “educational buildings.”
Health care properties	Analysis provided for facilities that care for the sick. Facilities that care for the aged are grouped with lodging properties in floor space data.	Analysis provided for “buildings for institutional care”; these could include either or both parts of health care and/or prisons and jails, though the word “care” suggests only health care is included.
Stores	Analysis provided for all store and mercantile properties; floor space data may exclude some properties such as gasoline service stations.	Analysis provided for “commercial buildings.”
Offices	Analysis provided for office properties, including fire stations.	Analysis provided for “office buildings”; fire stations are included in a separate category called “transport and firefighting and rescue service buildings.”
Residential	Analysis provided for residential other than home plus facilities that care for the aged, because that is how floor space data is grouped.	Analysis provided for “residential buildings” and separately for “buildings for institutional care.”

Table D.2(a) Rate of Fires (per year) Relative to Numbers of Buildings and Square Feet of Floor Space for Religious Properties

Statistic	Rate
Fires per year (to the nearest hundred)	2,100
Thousands of buildings with at least 1000 square ft^2	342.6
Millions of square feet in buildings with at least 1000 ft^2	3,552
Fires per thousand buildings per year	6.0
Fires per million square feet per year	0.58

Table D.2(b) Percentage of Fires with Flame Spread Beyond Room of Origin and Estimated Number of Fires Used as Basis for Percentages

Type of Construction	No Sprinklers		Sprinklers Present	
	No Detectors	Detectors Present	No Detectors	Detectors Present
Fire resistive	22% 1,982	6% 558	0% 33	0% 93
Protected, noncombustible	16% 776	7% 338	7% 29	3% 76
Unprotected, noncombustible	23% 819	15% 239	0% 2	43% 14
Protected, ordinary	24% 3,739	12% 1,095	14% 29	0% 145
Unprotected, ordinary	29% 4,637	18% 1,215	22% 27	5% 80
Protected, wood frame	33% 3,223	17% 885	6% 31	3% 60
Unprotected, wood frame	39% 5,290	20% 918	8% 26	18% 39

Sources: NFPA analysis of NFIRS; NFPA survey; Energy Information Administration Commercial Buildings Energy Consumption Surveys, building characteristics tables.
Note: These are 1989–1998 fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. These years are used because they are the latest for the type of construction that is included in the coded elements. All estimates are based on at least 200 reported fires (raw, not projected estimates) in the 10 years with the indicated data known. Buildings and floor space are estimated from 1992, 1995, and 1999 surveys, using linear interpolation and extrapolation for years before or between the three years when surveys were taken, resulting in a final formula of {(7 × 1992 estimate) + [1.5 × (1995 estimate + 1999 estimate)]}/10.

Table D.3(a) Rate of Fires (per year) Relative to Numbers of Buildings and Square Feet of Floor Space for Eating and Drinking Establishments

Statistic	Rate
Fires per year (to the nearest hundred)	11,400
Thousands of buildings with at least 1000 ft^2	277.1
Millions of square feet in buildings with at least 1000 ft^2	1,524
Fires per thousand buildings per year	41.2
Fires per million square feet per year	7.5

Table D.3(b) Percentage of Fires with Flame Spread Beyond Room of Origin and Estimated Number of Fires Used as Basis for Percentages

Type of Construction	No Sprinklers		Sprinklers Present	
	No Detectors	Detectors Present	No Detectors	Detectors Present
Fire resistive	16% 8,566	10% 2,090	5% 1,879	3% 2,893
Protected, noncombustible	16% 4,690	6% 1,482	4% 1,446	4% 2,003
Unprotected noncombustible	20% 4,991	10% 1,193	8% 896	5% 836
Protected, ordinary	19% 19,096	11% 5,034	6% 3,837	4% 4,623
Unprotected, ordinary	24% 24,670	14% 5,325	8% 2,917	5% 2,469
Protected, wood frame	22% 13,513	12% 3,499	8% 2,180	5% 2,210
Unprotected, wood frame	29% 23,985	19% 3,901	11% 1,902	7% 1,303

Sources: NFPA analysis of NFIRS; NFPA survey; Energy Information Administration Commercial Buildings Energy Consumption Surveys, building characteristics tables.
Note: These are 1989–1998 fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. These years are used because they are the latest for the type of construction that is included in the coded elements. All estimates are based on at least 200 reported fires (raw, not projected estimates) in the 10 years with the indicated data known. Buildings and floor space are estimated from 1992, 1995, and 1999 surveys, using linear interpolation and extrapolation for years before or between the three years when surveys were taken, resulting in a final formula of {(7 × 1992 estimate) + [1.5 × (1995 estimate + 1999 estimate)]}/10.

Table D.4(a) Rates of Fires (per year) Relative Numbers of Buildings and Square Feet of Floor Space for Other Public Assemblies

Statistic	Rate
Fires per year	4,200
Thousands of buildings with at least 1000 ft^2	289.3
Millions of square feet in buildings with at least 1000 ft^2	4,440
Fires per thousand buildings per year	14.5
Fires per million square feet per year	0.94

Table D.4(b) Percentage of Fires with Flame Spread Beyond Room of Origin and Estimated Number of Fires Used as Basis for Percentages

	No Sprinklers		Sprinklers Present	
Type of Construction	No Detectors	Detectors Present	No Detectors	Detectors Present
Fire resistive	13% 5,087	5% 1,757	4% 675	2% 2,163
Protected, noncombustible	16% 2,168	6% 815	3% 419	5% 1,077
Unprotected, noncombustible	20% 2,869	13% 727	4% 306	6% 343
Protected, ordinary	21% 5,593	11% 1,557	4% 580	3% 1,231
Unprotected, ordinary	31% 8,295	15% 1,604	5% 416	3% 511
Protected, wood frame	33% 3,248	18% 853	12% 316	5% 356
Unprotected, wood frame	43% 10,823	22% 1,282	10% 236	8% 250

Sources: NFPA analysis of NFIRS; NFPA survey; Energy Information Administration Commercial Buildings Energy Consumption Surveys, building characteristics tables.

Note: These are 1989–1998 fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. These years are used because they are the latest for the type of construction that is included in the coded elements. All estimates are based on at least 200 reported fires (raw, not projected estimates) in the 10 years with the indicated data known. Buildings and floor space are estimated from 1992, 1995, and 1999 surveys, using linear interpolation and extrapolation for years before or between the three years when surveys were taken, resulting in a final formula of {(7 × 1992 estimate) + [1.5 × (1995 estimate + 1999 estimate)]}/10.

D.5 Educational. Specific property use 200–299 includes grades K–12 and college classrooms but does not include dorms or other properties common to educational complexes.

The Finnish data on fires need to be converted from total fires for a multi-year period to average fires per year. Having done so, their rates of fires per million square feet were 0.18 for 1996–1999 and 0.28 for 1996–2001. However, one out of 20 buildings had unknown square feet, so it is possible these figures should be reduced by 5 percent. Either way, they are *lower* than the figures related to other educational properties for the United States. Their data on fires per thousand buildings showed 5.2 for 1996–2001 (no such data shown for 1996–1999). This is much *lower* than any comparable U.S. figures. For data on educational property use, see Table D.5(a) and Table D.5(b).

D.6 Facilities That Care for the Sick. Specific property use 330–339 includes hospitals and clinics. Floor space survey data include inpatient and outpatient facilities; nursing homes are included with lodging.

None of the Finnish categories seem to correspond well to this U.S. category. For data on facilities that care for the sick, see Table D.6(a) and Table D.6(b).

Table D.5(a) Rate of Fires (per year) Relative to Numbers of Buildings and Square Feet of Floor Space for Educational Complexes

Statistic	Rate
Fires per year	7,700
Thousands of buildings with at least 1000 ft^2	306.1
Millions of square feet in buildings with at least 1000 ft^2	8,388
Fires per thousand buildings per year	25.0
Fires per million square feet per year	0.91

Table D.5(b) Percentage of Fires with Flame Spread Beyond Room of Origin and Estimated Number of Fires Used as Basis for Percentages

	No Sprinklers		Sprinklers Present	
Type of Construction	**No Detectors**	**Detectors Present**	**No Detectors**	**Detectors Present**
Fire resistive	7% 12,140	3% 9,878	4% 1,017	2% 4,293
Protected, noncombustible	7% 5,544	4% 4,753	2% 689	3% 2,826
Unprotected, noncombustible	9% 4,040	4% 3,071	1% 251	2% 652
Protected, ordinary	8% 8,215	4% 6,025	5% 737	3% 2,786
Unprotected, ordinary	16% 6,169	8% 3,962	4% 308	5% 858
Protected, wood frame	18% 2,794	7% 1,595	5% 263	2% 647
Unprotected, wood frame	30% 5,108	13% 1,692	11% 179	3% 313

Sources: NFPA analysis of NFIRS; NFPA survey; Energy Information Administration Commercial Buildings Energy Consumption Surveys, building characteristics tables.

Note: These are 1989–1998 fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. These years are used because they are the latest for the type of construction that is included in the coded elements. All estimates are based on at least 200 reported fires (raw, not projected estimates) in the 10 years with the indicated data known. Buildings and floor space are estimated from 1992, 1995, and 1999 surveys, using linear interpolation and extrapolation for years before or between the three years when surveys were taken, resulting in a final formula of {(7 × 1992 estimate) + [1.5 × (1995 estimate + 1999 estimate)]}/10.

Table D.6(a) Rate of Fires (per year) Relative to Numbers of Buildings and Square Feet of Floor Space for Facilities that Care for the Sick

Statistics	Rate
Fires per year	3,000
Thousands of buildings with at least 1000 ft^2	78.9
Millions of square feet in buildings with at least 1000 ft^2	2,022
Fires per thousand buildings per year	37.8
Fires per million square feet per year	1.48

Table D.6(b) Percentage of Fires with Flame Spread Beyond Room of Origin and Estimated Number of Fires Used as Basis for Percentages

	No Sprinklers		Sprinklers Present	
Type of Construction	**No Detectors**	**Detectors Present**	**No Detectors**	**Detectors Present**
Fire resistive	3% 3,894	2% 7,660	2% 934	1% 13,624
Protected, noncombustible	3% 1,198	2% 2,157	2% 363	1% 5,704
Unprotected, noncombustible	8% 279	4% 448	0% 38	1% 590
Protected, ordinary	10% 952	3% 1,554	3% 325	2% 3,777
Unprotected, ordinary	17% 586	5% 594	0% 74	1% 659
Protected, wood frame	19% 236	7% 299	35% 23	2% 464
Unprotected, wood frame	14% 519	14% 306	0% 26	1% 223

Sources: NFPA analysis of NFIRS; NFPA survey; Energy Information Administration Commercial Buildings Energy Consumption Surveys, building characteristics tables.

Note: These are 1989–1998 fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. These years are used because they are the latest for the type of construction that is included in the coded elements. All estimates are based on at least 200 reported fires (raw, not projected estimates) in the 10 years with the indicated data known. Buildings and floor space are estimated from 1992, 1995, and 1999 surveys, using linear interpolation and extrapolation for years before or between the three years when surveys were taken, resulting in a final formula of {(7 × 1992 estimate) + [1.5 × (1995 estimate + 1999 estimate)]}/10.