Tentative Interim Amendment

NFPA 409

Standard on Aircraft Hangars

2004 Edition

Reference: 5.17.1*,5.17.2, 5.17.3 & 5.17.4
TIA 04-2 (NFPA 409)
(SC 06-7-22/Log No. 851)

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 409, *Standard on Aircraft Hangars,* 2004 edition. The TIA was processed by the Airport Facilities Committee, and was issued by the Standards Council on July 28, 2006, with an effective date of August 19, 2006.

A Tentative Interim Amendment is tentative because it has not been processed through the entire standards-making procedures. It is interim because it is effective only between editions of the standard. A TIA automatically becomes a proposal of the proponent for the next edition of the standard; as such, it then is subject to all of the procedures of the standards-making process

1. Revise section 5.17.1 as follows:*

5.17.1* Draft curtains shall be provided in Group I hangars and in Group II hangars where the protection requirements of paragraph 6.1.1(1) are utilized. Draft curtain areas shall be around each roof/ceiling fire suppression system and subdivided such that a single draft curtain area shall not exceed 697 m^2 (7500 ft^2). The maximum projected floor area under an individual sprinkler system shall be in accordance with Chapters 6 and 7.

2. Revise sections 5.17.2, 5.17.3 and 5.17.4 to be consistent with the change in section 5.17.1 as follows:

5.17.2 Where provided, draft curtains shall…
5.17.3 Where provided, draft curtains shall…
5.17.4 Where draft curtains are required, structural features…

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Tentative Interim Amendment

NFPA 409

Standard on Aircraft Hangars

2004 Edition

Reference: 7.5.8 & A.7.5.8
TIA 04-1 (NFPA 409)
(SC 05-4-37/Log No. 810)

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 409, *Standard on Aircraft Hangars,* 2004 edition. The TIA was processed by the Airport Facilities Committee, and was issued by the Standards Council on April 14, 2005, with an effective date of May 4, 2005.

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1. Replace the existing text in 7.5.8 with the following:

7.5.8 The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and service area. The design objective shall be to achieve coverage of the entire aircraft storage and servicing area to within 1.5 m (5 ft) of the perimeter walls and doors within 3 minutes of system actuation.

2. Delete the annex material A.7.5.8

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NFPA 409

Standard on Aircraft Hangars

2004 Edition



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NFPA 409

Standard on

Aircraft Hangars

2004 Edition

This edition of NFPA 409, *Standard on Aircraft Hangars*, was prepared by the Technical Committee on Airport Facilities and acted on by NFPA at its May Association Technical Meeting held May 23–26, 2004, in Salt Lake City, UT. It was issued by the Standards Council on July 16, 2004, with an effective date of August 5, 2004, and supersedes all previous editions.

This edition of NFPA 409 was approved as an American National Standard on August 5, 2004.

Origin and Development of NFPA 409

The original fire protection recommendations for the construction and protection of airplane hangars were published by the National Board of Fire Underwriters (NBFU), now the American Insurance Association, in 1930. Revisions were issued by the NBFU in 1931, 1943, 1945, and 1950. The 1943, 1945, and 1950 editions were published as NBFU Pamphlet 85. In 1951, the National Fire Protection Association organized a Committee on Aircraft Hangars, to which the NBFU and other interested groups lent their support. The NFPA's first standard on aircraft hangars was adopted in 1954, and the NBFU adopted the same text, rescinding its 1950 standard. Revisions were made in 1957 and 1958 by the NFPA committee. In 1959, a reorganization of the NFPA aviation activities resulted in the assignment of NFPA 409 to the Sectional Committee on Aircraft Hangars and Airport Facilities, which prepared the 1960, 1962, 1965, 1966, 1967, 1969, 1970, 1971, 1972, 1973, and 1975 editions. The sectional committee was reorganized as the Technical Committee on Airport Facilities and completed a revision to NFPA 409 in 1978. The document underwent extensive editorial revision and partial technical revision in 1984 and was again revised in 1990 and 1995.

For the 2001 edition, the fire protection requirements for Group I hangars were extensively revised and new criteria were added for membrane-covered rigid-steel-frame-structure hangars.

The 2004 edition of this standard is a partial revision.

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Committee Scope: This Committee shall have primary responsibility for documents on fire safety for the construction and protection at airport facilities involving construction engineering but excluding airport fixed fueling systems.

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NFPA 409

Standard on

Aircraft Hangars

2004 Edition

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A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for mandatory extracts are given in Chapter 2 and those for nonmandatory extracts are given in Annex C. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope. This standard contains the minimum requirements for the proper construction of aircraft hangars and protection of aircraft hangars from fire.

1.2 Purpose.

1.2.1* The purpose of this standard is to provide a reasonable degree of protection from fire for life and property in aircraft hangars, based on sound engineering principles, test data, and field experience.

1.2.2 No part of this standard is intended to restrict new technologies or alternative arrangements, provided the level of safety prescribed by the standard is not lowered.

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 10, *Standard for Portable Fire Extinguishers,* 2002 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2002 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems,* 1999 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2002 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2003 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2001 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2003 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2003 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2002 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2001 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 2003 edition.

NFPA 54, *National Fuel Gas Code,* 2002 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2004 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2002 edition.

NFPA 70, *National Electrical Code®,* 2005 edition.

NFPA 72®, National Fire Alarm Code®, 2002 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2002 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 2002 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.

NFPA *101®, Life Safety Code®,* 2003 edition.

NFPA 220, *Standard on Types of Building Construction,* 1999 edition.

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings,* 2003 edition.

NFPA 410, *Standard on Aircraft Maintenance,* 2004 edition.

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways,* 2002 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films,* 2004 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 2004 edition.

2.3 Other Publications. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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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* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.4 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1 Aircraft Access Door. Any opening through which any portion of the aircraft is passed to gain entry to the hangar.

3.3.2* Aircraft Hangar. A building or other structure inside any part of which aircraft are housed or stored, and in which aircraft might undergo service, repairs, or alterations.

3.3.3* Aircraft Storage and Servicing Area. That part of a hangar normally used for the storage and servicing of one or more aircraft, not including any adjacent or contiguous areas or structures, such as shops, storage areas, and offices.

3.3.4 Calculation Method.

3.3.4.1 ***Demand Calculation Method.*** Hydraulic calculation procedure for determining the minimum theoretical flow and pressure required to produce a minimum specified total discharge from a specific configuration of piping and discharge devices.

3.3.4.2 ***Supply Calculation Method.*** Hydraulic calculation procedure for determining the maximum theoretical flows and pressures in a system with a specific configuration of piping and discharge devices supplied by a water distribution system.

3.3.5 Detection System. A system consisting of detectors; controls; control panels; automatic and manual actuating mechanisms; all wiring, piping, and tubing; and all associated equipment that is used to actuate an extinguishing system.

3.3.6 Fire Wall. A wall separating buildings or subdividing a building to prevent the spread of fire and having a fire resistance rating and structural stability. [**221:**1.3]

3.3.7 Foam–Water Deluge System. A foam–water sprinkler system employing open discharge devices, which are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system, which is installed in the same areas as the discharge devices. When this valve opens, water flows into the piping system and discharges from all discharge devices attached thereto. [**16:**1.3]

3.3.8 Gross Wing Area. See 3.3.17, Wing Area.

3.3.9 Hangar Building Cluster. A group of buildings with more than one area for the storage and servicing of aircraft and all attached or contiguous structures, or structures not separated as specified in 8.3.1 of this standard, as appropriate.

3.3.10 Hangar Fire Area. An area within an aircraft hangar subject to loss by a single fire because of lack of internal subdivisions as specified in Section 5.2 or 8.2 of this standard, as appropriate.

3.3.11 Membrane Hangar. The flexible structural fabric or film that supports the imposed loads and transmits them to the supporting structure. The membrane carries only tension or shear in the plane of the membrane.

3.3.12* Paint Hangar. An aircraft hangar that is occupied primarily for the application of paint or other flammable or combustible liquids involving an entire aircraft or major portions of an aircraft.

3.3.13 Single Hangar Building. A building with one area for the storage and servicing of aircraft and any attached, adjoining, or contiguous structure, such as a lean-to, shop area, or parts storage area not separated as specified in Section 5.2 or 8.2 of this standard, as appropriate.

3.3.14 Tail Height. The maximum tail height as stated in aircraft manufacturers' specifications.

3.3.15 Unfueled Aircraft. An aircraft whose fuel system has had flammable or combustible liquid removed such that no tank, cell, or piping contains more than ½ percent of its volumetric capacity.

3.3.16 Weathered-Membrane Material. Membrane material that has been subjected to a minimum of 3000 hours in a weatherometer in accordance with ASTM G 155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials,* or approved equivalent. [***5000:***3.3]

3.3.17 Wing Area. Total projected area of clean wing (no projecting flaps, slats, and similar items) including all control surfaces and area of the fuselage bounded by the leading and trailing edges projected to the centerline (inapplicable to slender-delta aircraft with extremely large leading-edge sweep-angle). Net area excludes projected areas of fuselage, nacelles, and similar items.

Chapter 4 Aircraft Hangar Groups

4.1 Aircraft Hangar Classification. For the purposes of this standard, aircraft hangars shall be classified as follows.

4.1.1 Group I Aircraft Hangar. A Group I aircraft hangar shall have at least one of the following features and operating conditions:

(1) An aircraft access door height over 8.5 m (28 ft)
(2) A single fire area in excess of 3716 m^2 (40,000 ft^2)
(3) Provision for housing an aircraft with a tail height over 8.5 m (28 ft)

4.1.2 Group II Aircraft Hangar. A Group II aircraft hangar shall have both of the following features:

(1) An aircraft access door height of 8.5 m (28 ft) or less
(2) A single fire area for specific types of construction in accordance with Table 4.1.2

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Table 4.1.2 Fire Areas for Group II Aircraft Hangars

Type of Construction	Single Fire Area (Inclusive)	
	m^2	ft^2
Type I (443) and (332)	2,787–3,716	30,001–40,000
Type II (222)	1,858–3,716	20,001–40,000
Type II (111), Type III (211), and Type IV (2HH)	1,394–3,716	15,001–40,000
Type II (000)	1,115–3,716	12,001–40,000
Type III (200)	1,115–3,716	12,001–40,000
Type V (111)	743–3,716	8,001–40,000
Type V (000)	465–3,716	5,001–40,000

4.1.3* Group III Aircraft Hangar. A Group III hangar shall have both of the following features:

(1) An aircraft access door height of 8.5 m (28 ft) or less
(2) A single fire area that measures up to the maximum square footage permitted for specific types of construction in accordance with Table 4.1.3

Table 4.1.3 Maximum Fire Areas for Group III Aircraft Hangars

Type of Construction	Maximum Single Fire Area	
	m^2	ft^2
Type I (443) and (332)	2,787	30,000
Type II (222)	1,858	20,000
Type II (111), Type III (211), and Type IV (2HH)	1,394	15,000
Type II (000)	1,115	12,000
Type III (200)	1,115	12,000
Type V (111)	743	8,000
Type V (000)	465	5,000

4.1.4 Group IV Aircraft Hangar. A Group IV aircraft hangar shall be a structure constructed of a membrane-covered rigid steel frame.

Chapter 5 Construction of Group I and Group II Aircraft Hangars

5.1 Types of Construction.

5.1.1* Group I hangars shall be either Type I or Type II construction in accordance with NFPA 220. Group II hangars shall be constructed of any of the types of construction specified in NFPA 220 or any combination thereof.

5.1.2* Mezzanines, tool rooms, and other enclosures within aircraft storage and servicing areas shall be constructed of noncombustible material or limited-combustible material as defined in NFPA 220 in all hangars except those of Type V (111) and (000) construction.

5.2 Internal Separations.

5.2.1* Where aircraft storage and servicing areas are subdivided into separate fire areas, the separation shall be by a fire wall having not less than a 3-hour fire resistance rating. Any openings in such fire walls communicating directly between two aircraft storage and servicing areas shall be provided with a listed 3-hour fire door or 3-hour shutter actuated from both sides of the wall. Where areas are of different heights, the tallest wall shall have a fire resistance rating of not less than 3 hours.

5.2.2 Where two or more aircraft storage and servicing areas constituting separate fire areas are separated by continuous offices, shops, and parts storage areas, one of the two walls between the aircraft storage and servicing areas and the offices, shops, and parts storage areas shall comply with 5.2.1. The other wall shall comply with 5.2.3.

5.2.3* For aircraft hangars, other than those housing unfueled aircraft, partitions and ceilings separating aircraft storage and servicing areas from all other areas, shops, offices, and parts storage areas shall have at least a 1-hour fire resistance rating with openings protected by listed fire doors or shutters having a minimum fire resistance rating of 45 minutes.

5.2.4 For aircraft hangars, other than those housing unfueled aircraft, where a storage and servicing area has an attached, adjoining, or contiguous structure, such as a lean-to, shop, office, or parts storage area, the wall common to both areas shall have at least a 1-hour fire resistance rating, with openings protected by listed fire doors having a minimum fire resistance rating of 45 minutes and actuated from both sides of the wall.

5.3 Clear Space Distance Requirements Around Hangars.

5.3.1 Precautions shall be taken to ensure ready access to hangars from all sides. Adequate separation shall be provided to reduce fire exposure between buildings. The clear spaces specified in Table 5.3.2 shall not be used for the storage or parking of aircraft or concentrations of combustible materials, nor shall buildings of any type be erected therein.

5.3.2 For single hangar buildings, the clear space distances specified in Table 5.3.2 shall be maintained on all sides of the single hangar. Where mixed types of construction are involved, the less fire-resistant type of construction shall be used to determine the clear space required.

Table 5.3.2 Clear Space Distances for Single Hangar Buildings

Type of Construction	Minimum Separation Required	
	m	ft
Type I (443) and (332)	15	50
Type II (222)	15	50
Type II (111), Type III (211), and Type IV (2HH)	15	50
Type II (000)	15	50
Type III (200)	15	50
Type V (111) and (000)	23	75

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5.3.2.1 Where both exposing walls and openings therein of adjacent single hangar buildings have a minimum fire resistance rating of at least 3 hours, no minimum separation distance shall be required.

5.3.2.2 Where the exposing wall and any openings therein of one hangar have a minimum fire resistance rating of at least 2 hours, the minimum separation distance shall be permitted to be reduced to not less than 7.5 m (25 ft) for single hangar buildings.

5.3.2.3* Where the exposing walls of both buildings have a minimum fire resistance rating of at least 2 hours, with all windows protected by listed glass in fixed steel sash having a minimum fire resistance rating of 45 minutes, with outside sprinkler protection and each doorway protected with one automatically operated listed fire door having a minimum fire resistance rating of 1½ hours, the clear space distance shall be permitted to be reduced to not less than 7.5 m (25 ft) between single hangar buildings. Under such conditions, the glass area in the exposing walls shall be not more than 25 percent of the wall area.

5.4 Floors.

5.4.1 The surface of the grade floor of aircraft storage and servicing areas, regardless of type of hangar construction, shall be noncombustible and above the grade of the approach or apron at the entrance to the hangar.

5.4.2* The floors of adjoining areas that pose flammable or combustible liquid spill hazards and that connect with aircraft storage and servicing areas shall be noncombustible and shall be designed to prevent a spill from entering the aircraft storage and servicing area.

5.4.3 Floor openings in multistoried sections of hangars shall be enclosed with partitions or protected with construction having a fire resistance rating not less than that required for the floor construction where the opening is made.

5.5 Roofs.

5.5.1 Roof coverings shall be of an approved type of tile, slate, metal, or asphalt shingle or of built-up roofing finished with asphalt, slate, gravel, or other approved material. Roof coverings shall be listed as Class A or Class B when tested in accordance with NFPA 256.

5.5.2 Where insulated metal deck assemblies are used, they shall be equivalent to FM Class 1 or UL Fire Classified ratings.

5.5.3* Spaces under roofs, created where suspended ceilings are provided in aircraft storage and servicing areas, shall be cut off from the area below so that the space cannot be used for storage or other occupancy. The space shall be provided with ventilation louvers to ensure air circulation therein.

5.5.4 Permanent exterior ladders to hangar roofs shall be provided on all hangars exceeding 2323 m^2 (25,000 ft^2) in area, or exceeding 12 m (40 ft) in height, or exceeding 30 m (100 ft) in their smallest dimension.

Exception: Permanent exterior ladders to hangar roofs shall not be required where enclosed stairs leading directly to the roof of aircraft storage and servicing areas are available from the exterior of the hangar.

5.6 Columns.

5.6.1 In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, column protection shall be required in accordance with 5.6.2 through 5.6.4.

5.6.2 All main steel structural columns of the aircraft storage and servicing areas shall be made fire resistant using listed materials and methods to provide a fire-resistive rating of not less than 2 hours.

5.6.3* Fixed water or foam–water systems or additional discharge devices as an extension of the overhead system shall be permitted to be used in lieu of a 2-hour fire resistance rating, if such systems are designed specifically to protect the columns. Overspray from overhead sprinklers to protect columns shall not be permitted.

5.6.3.1 Distances between discharge devices vertically shall not exceed 3 m (10 ft).

5.6.4 All fire-resistant materials used to protect structural steel columns shall be of a type that resists damage from discharge of the fixed fire protection system.

5.7 Doors.

5.7.1 Hangar doors that accommodate aircraft shall be constructed of noncombustible or limited-combustible materials where hangars are of any Type I or Type II construction as specified in 5.1.1.

5.7.2 The power source for hangar doors shall operate on independent circuits and shall not be deenergized when the main disconnect switches for general hangar power are shut off.

5.7.3* Vertical traveling doors shall be counterbalanced, and horizontal slide or accordion-type doors shall be arranged so that manual or auxiliary operation by means of winches or tractors, for example, is feasible.

5.7.4 In areas where freezing temperatures can occur, door tracks or the bottom edges of doors shall be protected by heating coils or equivalent means to prevent ice formation that might prevent or delay operation.

5.8 Curtains. Where curtains are used to enclose a work area, they shall be of a listed flame-retardant type.

5.9 Landing Gear Pits, Ducts, and Tunnels.

5.9.1* Landing gear pits, ducts, and tunnels located below floor level shall be designed on the premise that flammable liquids and vapor will be present at all times. Materials and equipment shall be impervious to liquids and shall be fire resistant or noncombustible.

5.9.2 Electrical equipment for all landing gear pits, ducts, and tunnels located below hangar floor level shall be suitable for use in Class I, Division 1, Group D hazardous locations in compliance with Article 501 of NFPA 70.

5.9.3 All landing gear pits, ducts, and tunnels shall be provided with a positive mechanical exhaust ventilation system capable of providing a minimum rate of five air changes per hour during normal operations and be designed to discharge externally to the hangar.

5.9.4 Upon the detection of flammable vapors, the ventilation system shall be capable of providing a minimum ventilation rate of 30 air changes per hour for the landing gear pit and all associated ducts or tunnels.

5.9.5* The ventilation system shall be controlled by an approved continuous-reading combustible gas-analyzing system that is arranged to operate the ventilation system at the rate specified in 5.9.4 automatically upon detection of a specified

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flammable vapor concentration that is below the lower flammable limit (LFL). The detection system shall have sensors located throughout all ducts and tunnels.

5.9.6 Because entry of fuel, oil, and water into landing gear pits is inevitable, drainage or pumping facilities shall be provided.

5.9.6.1 Water-trapped vapor seals and appropriate separator fuel traps shall be provided.

5.9.6.2 Where automatic pumping facilities are necessary, they shall be suitable for use with aviation fuel and water.

5.9.6.3 The drainage shall be fully enclosed pipe runs if drainage is routed through ventilation or access tunnels to external discharge points.

5.9.7* Explosion protection shall be provided in landing gear pits, communicating ducts, and tunnel areas in the form of pressure-relief venting or by a listed explosion prevention system installed in accordance with NFPA 69.

5.9.8* An approved fire protection system shall be installed to protect each pit unless the hangar fire protection required by either Chapter 6 or Chapter 7 is adequate to protect each pit.

5.10 Exposed Interior Insulation. Exposed interior insulation attached to walls and roofs in an aircraft storage or servicing area of a hangar shall comply with the requirements of NFPA *101* special provisions for aircraft storage hangars, interior wall and ceiling finish criteria.

5.11 Drainage of Aprons and Hangar Floors.

5.11.1 Apron Drainage.

5.11.1.1 The apron or approach at the entrance to the hangar shall slope away from the hangar with a minimum grade of 0.5 percent (1:200) for the first 15 m (50 ft).

5.11.1.2 Ramps used for aircraft fueling adjacent to hangar structures shall comply with NFPA 415.

5.11.1.3 In establishing locations for nearby aircraft parking, consideration shall be given to the drainage pattern of the apron.

5.11.2 Hangar Floor Trench Drainage.

5.11.2.1 In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, floor trench drainage in accordance with 5.11.2.2 through 5.11.2.12 shall be provided.

5.11.2.2* Floor trench drainage systems shall be provided to restrict the spread of fuel in order to reduce the fire and explosion hazards from fuel spillage.

5.11.2.3 Trench drainage systems shall be designed to reduce fire and explosion hazards within the systems to the maximum extent by the use of noncombustible underground piping and by routing trench drainage as directly as possible to a safe outside location. Such systems shall be designed with suitable traps or be provided with adequate ventilation to prevent vapor mixtures from forming within the underground trench drainage system.

5.11.2.4* Trench drainage systems in aircraft storage or servicing areas shall be designed and constructed so that they have sufficient capacity to prevent buildup of flammable liquids and water over the drain inlet when all fire protection systems and hose streams are discharging at the design rate.

5.11.2.5 The pitch of the floor shall be a minimum of 0.5 percent. The floor pitch provided shall be calculated, taking into consideration the towing requirements of the aircraft and the factors of aircraft weight, balance checking, and maintenance.

5.11.2.6 Each trench drainage system shall be calculated separately, taking into consideration the maximum rated discharge based on the supply calculation method for the fire protection systems and hose lines.

5.11.2.7 The size of trench drainage piping shall be determined by the hydraulic demands placed on the system throughout its length.

5.11.2.8 Curbs, ramps, or drains shall be provided at all openings from aircraft storage and servicing areas, or the slope of the floor shall be such so as to prevent the flow of liquids through openings.

5.11.2.9 Pits for service facilities, such as for compressed air, electrical outlets, and so forth, shall drain into the floor trench drainage system.

5.11.2.10 Oil separators shall be provided for the trench drainage systems serving all aircraft storage and servicing areas. These separators shall be permitted to serve each hangar trench drainage system or a group of hangar trench drainage systems or be installed as part of a general airport trench drainage system.

5.11.2.11 In aircraft storage and servicing areas protected by water sprinkler systems or foam–water systems, a bypass shall be provided around the separator to allow for emergency direct disposal of water and flammable liquids. Separator systems shall discharge flammable liquid products to a safely located tank, cistern, or sump.

5.11.2.12 Grates and drain covers shall be of sufficient strength to support the point loading of the heaviest type aircraft or equipment that the hangar might serve. Grates and covers shall be removable to facilitate cleaning and flushing.

5.12 Heating and Ventilating.

5.12.1* Heating, ventilating, and air-conditioning equipment shall be installed, as applicable, in accordance with NFPA 90A, NFPA 31, NFPA 54, NFPA 90B, and NFPA 58.

5.12.2 In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, or sections communicating therewith, no heating, ventilating, and air-conditioning equipment employing an open flame or glowing element shall be installed, other than as provided for in 5.12.5.

5.12.3 In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, hangar heating plants that are fired with gas, liquid, or solid fuels not covered under 5.12.5 and that are not located in a detached building shall be located in a room separated from other parts of the hangar by construction having at least a 1-hour fire resistance rating.

5.12.3.1 This separated room shall not be used for any other hazardous purpose or combustible storage and shall have no direct access from the aircraft storage or servicing area.

5.12.3.2 Openings in the walls of such rooms communicating with other portions of the hangar shall be restricted to those necessary for ducts or pipes.

5.12.3.3 Penetrations of the 1-hour fire resistance rated enclosure shall be firestopped with an approved material properly installed and capable of maintaining the required fire resistance rating for the enclosure.

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5.12.3.4 Each such duct shall be protected with a listed automatic fire damper or door.

5.12.3.5 All air for combustion purposes entering such separated rooms shall be drawn from outside the building.

5.12.4* In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, heating, ventilating, and air-conditioning systems employing recirculation of air within aircraft storage and servicing areas shall have return air openings not less than 3 m (10 ft) above the floor. Supply air openings shall not be installed in the floor and shall be at least 152 mm (6 in.) from the floor measured to the bottom of the opening.

5.12.4.1 Where automatic fire protection systems are installed in aircraft storage and servicing areas, fans for furnace heating systems shall be arranged to shut down automatically by means of the operation of the interior automatic fire protection system.

5.12.4.1.1 One or more manual fan shutoff switches shall be provided.

5.12.4.1.2 Shutoff switches shall be accessible and clearly placarded.

5.12.5 Suspended or Elevated Heaters.

5.12.5.1 In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, listed electric, gas, or oil heaters shall be permitted to be used if installed as specified in 5.12.5.2 through 5.12.5.4.

5.12.5.2 In aircraft storage and servicing areas, heaters shall be installed at least 3 m (10 ft) above the upper surface of wings or of the engine enclosures of the highest aircraft that might be housed in the hangar. The measurement shall be made from the wing or engine enclosure, whichever is higher from the floor, to the bottom of the heater.

5.12.5.3 In shops, offices, and other sections of aircraft hangars communicating with aircraft storage or servicing areas, the bottom of the heaters shall be installed not less than 2.4 m (8 ft) above the floor.

5.12.5.4 In all hangars, suspended or elevated heaters shall be located in spaces where they shall not be subject to injury by aircraft, cranes, movable scaffolding, or other objects. Provisions shall be made to ensure accessibility to suspended heaters for recurrent maintenance purposes.

5.12.6 Where a mechanical ventilating system is employed in hangars or shops, the ventilating system shall be installed in accordance with NFPA 90A.

5.12.7 Where blower and exhaust systems are installed for vapor removal, the systems shall be installed in accordance with NFPA 91.

5.13 Lighting and Electrical Systems.

5.13.1 Artificial lighting shall be restricted to electric lighting.

5.13.2* Electrical services shall be installed in compliance with the provisions for aircraft hangars contained in Article 513 of NFPA 70.

5.13.3 In aircraft storage and servicing areas of hangars housing other than unfueled aircraft, main distribution panels, metering equipment, and similar electrical equipment shall be located in a room separated from the aircraft storage and servicing areas by a partition having at least a 1-hour fire resistance rating. The partition shall not be penetrated except by electrical raceways, which shall be protected by approved sealing methods maintaining the same fire resistance rating as the partition.

5.14* Lightning Protection. Where provided, lightning protection shall be installed in accordance with NFPA 780.

5.15 Grounding Facilities for Static Electricity.

5.15.1* Aircraft storage and servicing areas of hangars housing other than unfueled aircraft shall be provided with grounding facilities for removal and control of static electrical accumulations on aircraft while aircraft are stored or undergoing servicing in a hangar in accordance with 5.15.2 and 5.15.3.

5.15.2 An adequate number of floor-grounding receptacles shall be provided. The receptacles shall be either grounded through individual driven electrodes or electrically bonded together in a grid system and the entire system grounded to underground metal piping, such as cold water or sprinkler piping, or driven electrodes. Where driven electrodes are used, they shall consist of 15.9 mm (⅝ in.) diameter or larger metal rods driven at least 1.5 m (5 ft) into the ground. Floor-grounding receptacles shall be designed to minimize the tripping hazard.

5.15.3* Grounding wires shall be bare and of a gauge that is satisfactorily durable to withstand mechanical strains and usage.

5.16 Exit and Access Requirements.

5.16.1 Means of egress from the aircraft hangar shall comply with NFPA *101*.

5.16.2 Aisles and clear space shall be maintained to ensure access to sprinkler control valves, standpipe hose, fire extinguishers, and similar equipment.

5.17* Draft Curtains.

5.17.1* Draft curtains shall be provided. Draft curtain areas shall be around each roof/ceiling fire suppression system and subdivided such that a single draft curtain area shall not exceed 697 m^2 (7500 ft^2). The maximum projected floor area under an individual sprinkler system shall be in accordance with Chapters 6 and 7.

5.17.2 Draft curtains shall be constructed of noncombustible materials not subject to disintegration or fusion during the early stages of a fire and shall be tightly fitted to the underside of the roof or ceiling. Any opening in draft curtains shall be provided with self-closing doors constructed of materials equivalent in fire resistance to the draft curtain itself.

5.17.3 Draft curtains shall extend down from the roof or ceiling of aircraft storage and servicing areas not less than one-eighth of the height from the floor to the roof or ceiling. Under curved or sloping roofs extending to grade level or close to grade level, draft curtains need not be continued below 4.8 m (16 ft) from the floor.

5.17.4 Structural features of a building that serve the purpose of draft curtains shall be permitted in lieu of specially constructed draft curtains provided they meet the dimensional requirements of 5.17.3.

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Chapter 6 Protection of Group I Aircraft Hangars

6.1 General.

6.1.1 The protection of aircraft storage and servicing areas for Group I aircraft hangars, other than those housing unfueled aircraft, shall be in accordance with any one of the following:

(1) A foam–water deluge system, as specified in 6.2.2. In addition, supplementary protection systems as specified in 6.2.3 shall be provided in hangars housing single aircraft having wing areas greater than 279 m^2 (3000 ft^2).
(2) A combination of automatic sprinkler protection in accordance with 6.2.4 and an automatic low-level low-expansion foam system in accordance with 6.2.5.
(3) A combination of automatic sprinkler protection in accordance with 6.2.4 and an automatic low-level high-expansion foam system in accordance with 6.2.5.

6.1.2 Group I aircraft hangar storage and service areas housing unfueled aircraft shall be provided with automatic sprinkler protection as specified in Sections 7.2 and 7.8.

6.1.3 Automatic sprinkler protection shall be provided inside separate shop, office, and storage areas located inside aircraft maintenance and servicing areas, unless they are otherwise provided with automatic fire protection systems.

6.1.4 Each sprinkler system shall be designed and installed in accordance with NFPA 13 and NFPA 16, as applicable, and in accordance with the requirements of this chapter.

6.1.5 Additional protection, as specified in 6.2.9 and Sections 6.3 and 6.4, shall be provided in all Group I aircraft hangars in addition to other protection systems required by this chapter.

6.2 Fire Protection Systems.

6.2.1 Plans and Specifications.

6.2.1.1* Before systems are installed, complete specifications and working plans shall be drawn to scale showing all essential details, and plans shall be easily reproducible to provide necessary copies.

6.2.1.2 Information supplied in these plans and specifications shall be in accordance with NFPA 13 and shall include the following:

(1) Design purpose of the systems
(2) Discharge densities and the period of discharge
(3) Hydraulic calculations
(4) Details of tests of the available water supply
(5) Details of proposed water supplies
(6) Detailed layout of the piping and of the detection systems
(7) Make and type of discharge devices, operating equipment, and foam concentrate to be installed
(8) Location and spacing of discharge devices
(9) Pipe hanger and bracing location and installation details
(10) Location of draft curtains
(11) Accurate and complete layout of the area to be protected, including drainage layout
(12) Details of any foam concentrate, its storage and injection, and other pertinent data to provide a clear explanation of the proposed design
(13) Location and spacing of supplementary or low-level agent distributors, showing the area of coverage
(14) Installation layout of the actuation systems
(15) Detailed layout of water supply piping, agent storage, pumping and piping, power sources, and location and details of mechanical foam–liquid concentrate injection equipment

6.2.2 Deluge Foam–Water Sprinkler System Design and Performance.

6.2.2.1 In aircraft storage and servicing areas, each sprinkler system shall be designed in accordance with NFPA 13 and NFPA 16, as applicable, and in accordance with this chapter.

6.2.2.2* In aircraft storage and servicing areas, the maximum projected floor area under an individual deluge system shall not exceed 1394 m^2 (15,000 ft^2).

6.2.2.3 In aircraft storage and servicing areas, the protection area as projected on the floor shall be limited to 12 m^2 (130 ft^2). The maximum distance between sprinklers either on branch lines or between branch lines shall be 3.7 m (12 ft).

6.2.2.4 System piping shall be hydraulically designed using two separate calculation methods.

6.2.2.4.1 The demand calculation method shall be performed to determine the adequacy of the water supply.

6.2.2.4.2 The supply calculation method shall be performed to determine the amount of foam concentrate required.

6.2.2.4.3 Where steel pipe is installed, the coefficient C in the Hazen and Williams formula shall be taken as 120 in the calculations.

6.2.2.5 In other portions of hangars protected by sprinklers, the spacing shall be in accordance with the hazard requirements of the areas involved.

6.2.2.6 Uniform sprinkler discharge shall be based on a maximum variation of 15 percent between the sprinkler providing the lowest density and the sprinkler providing the greatest density within an individual deluge system as specified in 6.2.2.12 or 6.2.2.13.

Exception: Local application protection for columns shall not be required to comply with the maximum variation of 15 percent.

6.2.2.6.1 Variation below the required density shall not be permitted.

6.2.2.6.2 Orifice plates, sprinklers of different orifice sizes, piping of less than 25.4 mm (1 in.) diameter, or multiple fittings installed between a branch line fitting and an individual sprinkler for the sole purpose of increasing pressure loss shall not be permitted as a means to limit discharge.

6.2.2.7* Where open hangar doors result in interference with the distribution of overhead systems, additional devices shall be provided to ensure effective floor coverage.

6.2.2.8 Foam–water deluge systems discharge devices shall be either air-aspirating or non-air-aspirating and shall have deflectors designed to produce water discharge patterns closely comparable to those of spray sprinklers as defined in NFPA 13 when discharging at the same rates of flow.

6.2.2.9 The discharge devices shall generate foam where supplied with the foam solution under pressure and shall distribute the foam in a pattern essentially similar to that of water discharging therefrom.

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6.2.2.10 The discharge devices shall have a minimum nominal 6.4 mm (¼ in.) orifice and shall be listed for use with the particular type of foam concentrate to be used in the system.

6.2.2.11 Strainers shall be installed in accordance with NFPA 16.

6.2.2.12 The discharge density from air-aspirating discharge devices using protein foam, fluoroprotein foam, or aqueous film-forming foam (AFFF) solutions shall be a minimum of 8.1 L/min/m^2 (0.20 gpm/ft^2) of floor area.

6.2.2.13 The discharge density from non-air-aspirating discharge devices using AFFF solution shall be a minimum of 6.5 L/min/m^2 (0.16 gpm/ft^2) of floor area.

6.2.3 Supplementary Protection Systems.

6.2.3.1* Hangars protected in accordance with 6.1.1(1) and housing aircraft having wing areas in excess of 279 m^2 (3000 ft^2) shall be protected with a listed supplementary protection system.

6.2.3.2* Each system shall be designed to cover a specified floor area beneath the aircraft being protected. The design objective shall be to achieve control of the fire within the protected area within 30 seconds of system actuation and extinguishment of the fire within 60 seconds.

6.2.3.3 Each supplementary protection system shall be designed, installed, and maintained in accordance with NFPA 11 or NFPA 11A.

6.2.3.4 Supplementary Low-Expansion Foam Systems.

6.2.3.4.1 Supplementary low-expansion foam systems shall employ AFFF, protein, or fluoroprotein foam–liquid concentrates and shall be designed for local application.

6.2.3.4.2* Where oscillating nozzles are used, the discharge pattern limits shall be established for the design. Positive securement of the limits of oscillation shall be provided by such devices as set screws, locking pins, or similar methods. When placed in service, the manual override feature, if any, shall be locked out to provide for automatic operation only.

6.2.3.4.3 Where protein- or fluoroprotein-based concentrates are used, the minimum application rate of foam solution shall be 6.5 L/min/m^2 (0.16 gpm/ft^2) of floor area beneath the wings and wing center section of the aircraft. Where AFFF concentrate is used, the minimum application rate shall be 4.1 L/min/m^2 (0.10 gpm/ft^2) of floor area beneath the wings and wing center section of the aircraft.

6.2.3.4.4 If any nozzles are removed to allow movement of the aircraft, removal of the nozzles shall not reduce the effectiveness of the remaining system.

6.2.3.4.5 Electric power reliability for oscillating nozzles shall be in accordance with electric fire pump requirements of NFPA 20.

6.2.3.4.6 Where monitor-type nozzles are used, an individual manual control valve shall be provided for each unit. This valve shall be supervised.

6.2.3.5 Supplementary High-Expansion Foam Systems.

6.2.3.5.1 Supplementary high-expansion foam systems shall utilize surfactants as the foaming ingredient and shall be designed for local application.

6.2.3.5.2* These systems shall be designed to discharge at a rate to cover the protected area to a depth of at least 0.9 m (3 ft) within 1 minute.

6.2.3.5.3 Discharge rates shall take into consideration the sprinkler breakdown factor required in 2.3.5.2(b) of NFPA 11A.

6.2.3.5.4 The foam generators shall be located at the ceiling or on exterior walls in such a way that only air from outside the aircraft storage and servicing area can be used for foam generation. Roof vents shall be located to avoid recirculation of combustion products into the air inlets of the foam generators.

6.2.3.5.5* Generators shall be powered by reliable water-driven or electric motors. Electric power reliability for generators shall be in accordance with electric fire pump requirements of NFPA 20.

6.2.4 Closed-Head Water Sprinkler Systems for Aircraft Storage and Servicing Areas.

6.2.4.1* Sprinkler systems shall be either wet pipe or preaction, designed and installed in accordance with the applicable sections of NFPA 13 and the provisions of this chapter.

6.2.4.2 Sprinkler piping shall be hydraulically sized in accordance with NFPA 13. The maximum system size shall not exceed 4831 m^2 (52,000 ft^2).

6.2.4.3 Sprinkler spacing shall be as specified in 6.2.2.3.

6.2.4.4 Where open hangar doors result in interference with the distribution of water from the hangar sprinkler systems, additional sprinklers shall be provided to ensure effective floor coverage.

6.2.4.5 The design density of water from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm/ft^2) over any 1394 m^2 (15,000 ft^2) area, including the hydraulically most demanding area as defined in NFPA 13.

6.2.4.6 Sprinklers shall be nominal K-5.6 or K-8.0 sprinklers.

6.2.4.7 Quick-response sprinklers having a temperature rating of 79.4°C (175°F) shall be used. Quick-response sprinklers having a temperature rating of 93.3°C (200°F) shall be permitted in areas subject to high ambient temperatures.

6.2.4.8 Sprinkler systems shall be flushed and tested in accordance with NFPA 13.

6.2.5 Low-Level Foam Protection Systems.

6.2.5.1 Hangars protected in accordance with 6.1.1(2) or 6.1.1(3) shall be protected with a listed low-level foam protection system.

6.2.5.2 Each low-level foam protection system shall be designed, installed, and maintained in accordance with NFPA 11 or NFPA 11A.

6.2.5.3* The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and service area. The design objective shall be to achieve coverage of the entire aircraft storage and servicing area to within 1.5 m (5 ft) of the perimeter walls and doors within 3 minutes of system actuation.

6.2.5.4 Low-Level Low Expansion Foam Systems. Foam systems shall be of the fixed type and shall be designed and installed in accordance with the requirements for fixed-type systems in NFPA 11.

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6.2.5.4.1 Where AFFF concentrate is used, the minimum application rate of foam solution shall be 4.1 L/min/m^2 (0.10 gpm/ft^2). The minimum application rate of foam solution shall be 6.5 L/min/m^2 (0.16 gpm/ft^2) where protein-based or fluoroprotein-based concentrate is used.

6.2.5.4.2* The discharge rate of the system shall be based on the rate of application multiplied by the entire aircraft storage and servicing floor area.

6.2.5.4.3 The foam system shall use low-level discharge nozzles. Where monitor nozzles are used, they shall be provided with individual manual shutoff valves for each nozzle. The discharge nozzles shall be arranged to achieve initial foam coverage in the expected aircraft parking area.

6.2.5.4.4* Nozzles shall be located and installed so that aircraft positioning and workstand placement will not necessitate removal or repositioning of nozzles. All nozzle settings shall be marked and permanently secured in position after installation and acceptance testing.

6.2.5.4.5 Electric power reliability for oscillating nozzles shall be in accordance with electric fire pump requirements of NFPA 20.

6.2.5.5 Low-Level High-Expansion Foam Systems.

6.2.5.5.1 Low-level high-expansion foam systems shall be designed and installed in accordance with requirements for local application systems of NFPA 11A.

6.2.5.5.2 The effective application rate shall be a minimum of 0.9 m^3/min/m^2 (3 ft^3/min/ft^2).

6.2.5.5.3 The discharge rate of the system shall be based on the application rate multiplied by the entire aircraft storage and servicing floor area. The application total discharge rate shall include the sprinkler breakdown factor specified in 2.3.5.2(b) of NFPA 11A.

6.2.5.5.4 The high-expansion foam generators shall be arranged to achieve initial foam coverage in the expected aircraft parking area.

6.2.5.5.5 Foam generators shall be supplied with air from outside the aircraft storage and servicing area. Roof vents shall be located to avoid recirculation of combustion products into the air inlets of the foam generators.

6.2.5.5.6* Foam generators shall be powered by reliable water-driven or electric motors. Electric power reliability for foam generators shall be consistent with electric fire pump requirements specified in Chapters 6 and 7 of NFPA 20.

6.2.6* Foam Concentrate Supply. The friction losses in piping carrying foam concentrate shall be calculated using the Darcy formula, also known as the Fanning formula.

6.2.6.1 Where foam concentrate is introduced into the water stream by pumping, the total foam concentrate pumping capacity shall be such that the maximum pressures and flows can be met with the largest foam concentrate pump out of service.

6.2.6.2* The quantities of low-expansion foam concentrate, either protein foam, fluoroprotein, or AFFF, shall be sufficient for a 10-minute foam discharge based on the supply calculation in 6.2.2.4.

6.2.6.3* The quantity of high-expansion foam concentrate shall be sufficient for a 12-minute discharge at the water flow rate based on the supply calculation method required in 6.2.2.4.

6.2.6.4 A reserve supply of foam concentrate of compatible type for the system shall be directly connected to the system and readily available. The reserve supply shall be in the same quantity as the main supply. To prevent accidental depletion of this reserve supply, it shall be available to the system only by intentional manual operation.

6.2.6.5 Control valves, foam concentrate liquid storage tanks, concentrate pumps, controllers, and bypass balancing equipment shall be located outside the aircraft storage and service area.

6.2.7 Foam Concentrate Pumps.

6.2.7.1 Foam concentrate pump installations shall comply with the applicable provisions of NFPA 20, except as modified by this standard.

6.2.7.2* Where foam concentrate is introduced into the water stream by pumping, the total foam concentrate pumping capacity shall be such that the maximum flows and pressures can be met with the largest foam concentrate pump out of service. The reserve pump(s) shall be arranged to operate only upon failure of the primary pump(s).

6.2.7.3 Piping shall be arranged so that maximum foam concentrate demand can be supplied by any foam concentrate pump from either primary or reserve foam concentrate tanks.

6.2.7.4 Foam concentrate pumps shall be provided with means of pressure relief from the pump discharge to prevent excessive pressure and temperature. Discharge from the relief valve shall be piped back to the foam concentrate storage tank. Connection to the suction piping shall not be permitted.

6.2.7.5 The pressure regulating valve shall not be considered as the pressure relief valve. Foam concentrate pumps shall be started automatically by either a pressure drop in the foam concentrate piping system or a signal from the detection system control panel.

6.2.7.6 A pressure maintenance pump shall be provided to maintain pressure in the foam concentrate piping system where foam concentrate lines to the protective system injection points are run underground or where they run aboveground for more than 50 ft (15 m).

6.2.7.7 Once started, foam concentrate pumps shall be arranged to run continuously until stopped manually. There shall be an audible "pump running" alarm in a constantly attended location.

6.2.7.8 Power supply for the drivers of foam concentrate pumps shall be installed in accordance with NFPA 20 and NFPA 70. Power supplies shall be arranged such that disconnecting power to the protected facility during a fire shall not disconnect the power supply to the foam concentrate pump feeder circuit.

6.2.7.9 Controllers for foam concentrate pumps shall be as follows:

(1) For electric-drive foam concentrate pumps greater than 30 horsepower, a listed electric foam pump controller shall be used.
(2) For electric-drive foam concentrate pumps not exceeding 30 horsepower, a listed electric foam pump controller or limited-service foam pump controller shall be used.
(3) For diesel engine–driven foam concentrate pumps, a listed fire pump controller shall be used.

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6.2.8 Detection and Actuation System Design.

6.2.8.1 General.

6.2.8.1.1 Actuation systems shall be provided with complete circuit supervision and shall be arranged in accordance with Section 6.4.

6.2.8.1.2 These detectors shall be installed in accordance with *NFPA 72.*

6.2.8.1.3 Detection systems shall be provided with supervision as required by *NFPA 72.*

6.2.8.2 Deluge Foam–Water Sprinkler Systems.

6.2.8.2.1 Detectors for actuating the deluge foam–water sprinkler systems shall be rate-of-rise, fixed-temperature, or rate-compensation types.

6.2.8.2.2* Manual actuation stations shall be located so that each system can be individually operated from both inside and outside the aircraft storage and servicing area. The manual stations shall be installed so that they are unobstructed, readily accessible, and located in the normal paths of exit from the area.

6.2.8.3 Supplementary Protection Systems.

6.2.8.3.1* Actuation of any deluge foam–water sprinkler system shall simultaneously operate the supplementary protection system.

6.2.8.3.2 Manual actuation stations shall be provided for each supplementary protection system and shall be located both inside and outside the aircraft maintenance and servicing area. Stations shall be located as close as possible to the aircraft positions to facilitate early system actuation in the event of a fire.

6.2.8.4 Closed-Head Water Sprinkler Systems. Where preaction sprinkler systems are provided, detectors for actuating the systems shall be rate-of-rise, fixed-temperature, or rate-compensation type.

6.2.8.5 Low-Level Foam Protection Systems.

6.2.8.5.1* Actuation of any closed-head sprinkler system shall simultaneously operate the low-level foam protection system.

6.2.8.5.2 Manual actuation stations shall be provided for each low-level protection system and shall be located both inside and outside the aircraft maintenance and servicing area. Stations shall be located as close as possible to the aircraft postitions to facilitate early system actuation in the event of a fire.

6.2.9* Hand Hose Systems.

6.2.9.1 Hand hose systems shall be installed in every hangar to provide for manual fire control.

6.2.9.2 The hand hose systems shall be arranged to permit application of water or other extinguishing agents on each side and into the interior of the aircraft located in each aircraft storage and servicing area. At least two hose lines shall be considered to be operated simultaneously.

6.2.9.3 Foam–Water Hand Hose Systems.

6.2.9.3.1 Foam–water hand hose systems shall be installed in aircraft storage and servicing areas.

Exception: Where aircraft storage and servicing areas house only unfueled aircraft, as defined in 3.3.15, hand hose systems shall be provided in accordance with 6.2.9.4 of this standard.

6.2.9.3.2 The systems shall conform with the applicable portions of NFPA 14 and NFPA 11.

6.2.9.3.3 These hand hose systems shall be supplied from a connection to the sprinkler system header or from a direct connection to the water source.

6.2.9.3.4 Each hand hose connection shall be a minimum of 38 mm (1½ in.) in size and fitted with a control valve. The hose shall be of suitable length and diameter to provide a minimum flow of 227 L/min (60 gpm) at an adequate nozzle pressure. The stream range shall be calculated based on the volume and pressures available under maximum demand conditions.

6.2.9.3.5 The hose shall be properly racked or reeled. Hose shall be fitted with an approved foam-maker nozzle or a combination-type nozzle designed to permit foam application or water spray. Nozzles shall be of the shutoff type or shall have a shutoff valve at the nozzle inlet.

6.2.9.3.6 Foam–liquid concentrate shall be permitted to be supplied from a central distribution system, separate from or a part of a foam–water sprinkler system, or from stationary foam–liquid concentrate containers fitted with listed proportioning devices.

6.2.9.3.7 The minimum supply of foam–liquid concentrate shall be sufficient to provide operation of at least two hand hose lines for a period of 20 minutes at a foam solution discharge rate of 227 L/min (60 gpm) each.

6.2.9.4 Water Hand Hose Systems.

6.2.9.4.1 Water hand hose and standpipe systems shall be installed in accordance with NFPA 14 in all shop, office, and non-aircraft-storage areas in hangars, except where special hazards that require special protection exist.

6.2.9.4.2 Hoses shall be fitted with listed adjustable stream pattern nozzles designed to permit straight stream or water spray application.

6.2.10 Water Supply.

6.2.10.1* The total water supply shall be sufficient to satisfy the combination of systems as described in 6.1.1(1), 6.1.1(2), and 6.1.1(3) and the requirements for hose stream and other equipment as determined in 6.2.9. Water shall be available in sufficient quantity and pressure to supply the maximum number of discharge devices likely to operate simultaneously. Water shall be suitable for the production of foam.

6.2.10.2 Deluge Foam–Water Sprinkler Systems.

6.2.10.2.1* The water supply shall be capable of furnishing water for the largest number of systems that possibly could be expected to operate. Sufficient water supply requirements are determined by assuming that a fire at any point will operate all the systems in every draft-curtained area that is wholly or partially within a 30 m (100 ft) radius of that point measured horizontally.

6.2.10.2.2 The water supply shall be capable of maintaining water discharge at the design rate and pressure for a minimum of 60 minutes covering the entire area protected by systems expected to operate simultaneously, unless protection is provided as specified in 6.2.10.3.

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6.2.10.3 Supplementary Protection Systems. Where supplementary protection is installed in accordance with 6.2.3, the total water supply duration shall be for a minimum of 45 minutes.

6.2.10.4 Closed-Head Water Sprinkler Systems and Low-Level Foam Protection Systems. The water supply for the combination of closed-head water sprinkler systems and low-level foam protection systems shall have a minimum duration of 45 minutes.

6.2.10.5 Hand Hose Systems. The water supply for hand hose systems shall be capable of satisfying the requirements of 6.2.9 of this standard. The demand shall be calculated at the point where supply piping for the hand hose systems connects to the system piping or fire protection underground.

6.2.10.6 Exterior Hose Streams. Where the water supply for the systems also serves as a supply for exterior hose streams, a hose stream allowance of 1893 L/min (500 gpm) shall be included in the water supply hydraulic calculations. Calculations for hose stream shall be in accordance with NFPA 13.

6.2.10.7* Water Reservoirs. Where a single reservoir is used for the basic water supply, such reservoir shall be divided into approximately equal sections, arranged so that at least one-half of the water supply will always be maintained in service in order to increase the reliability of the water supply. The suction line from each section shall be sized to deliver the maximum water supply requirement.

6.2.10.8 Fire Pumps.

6.2.10.8.1 Fire pumps shall be installed in accordance with NFPA 20 and in accordance with the provisions of 6.2.10.8.2 through 6.2.10.8.6.

6.2.10.8.2 The total pumping capacity shall be such that maximum demand can be met with the largest fire pump out of service.

6.2.10.8.3 Pump houses and rooms shall be of fire-resistive or noncombustible construction. Where internal combustion engines used for driving fire pumps are located inside the fire pump house or room, protection shall be provided by automatic sprinklers installed in accordance with NFPA 13.

6.2.10.8.4* Fire pumps shall be started automatically by either a drop in water pressure or a signal from the detection control panel. Where two or more fire pumps are used, they shall be provided with automatic sequential starting.

6.2.10.8.5 Frequent operation of fire pumps shall be avoided by the installation of a small auxiliary pressure maintenance pump or other suitable means to maintain normal system pressures.

6.2.10.8.6 Once started, fire pumps shall be arranged to run continuously until they are stopped manually. There shall be an audible "pump running" alarm in a constantly attended area.

6.2.10.9* Flushing Underground Pipe. Underground mains and each lead-in connection shall be flushed as specified in NFPA 15.

6.2.11 Acceptance Tests. The following tests shall be performed prior to final acceptance of any fire protection system in an aircraft hangar.

6.2.11.1 Hydrostatic pressure tests shall be conducted on each system as specified in NFPA 11, NFPA 11A, NFPA 13, NFPA 14, or NFPA 16, as applicable.

6.2.11.2 All devices and equipment installed as part of the system shall be tested.

6.2.11.3 Full-flowing tests with water only shall be made on each foam–water deluge system as a means of checking the sprinkler distribution and to ensure against clogging of piping and sprinklers by foreign matter carried by the water. The maximum number of systems that possibly could be expected to operate in case of fire, including supplementary systems, shall be in full operation simultaneously to provide a check on the adequacy and condition of the water supply. Suitable gauge connections and gauges shall be provided to verify hydraulic calculations.

6.2.11.4 The smallest single foam–water deluge system shall be discharged using foam concentrate. This test shall be run for a length of time sufficient to stabilize discharge before test samples are taken to determine foam concentrate percentage.

6.2.11.5 The maximum number of systems expected to operate shall be simultaneously discharged with foam. This test shall be run for a length of time sufficient to stabilize discharge before test samples are taken to determine foam concentrate percentage.

6.2.11.6 Any proportioner not tested under the requirements of 6.2.11.4 or 6.2.11.5 shall be individually tested with foam concentrate to determine concentrate percentage.

6.2.11.7 Supplementary and low-level protection systems shall be subjected to foam flow tests, with foam flowing simultaneously from the maximum number of sprinkler systems expected to operate, in order to ensure that the hazard is protected in conformance with the design specification and to determine whether the flow pressures, agent discharge capacity, foam coverage, percent concentration, and other operating characteristics are satisfactory.

Exception: Where separate proportioning systems are utilized for the foam–water deluge sprinklers and the supplementary protection systems, water only shall be permitted to be flowed in the foam–water deluge sprinkler systems simultaneously with foam in the supplementary protection system.

6.2.11.8 Supplementary and low-level protection systems shall be examined visually to determine that they have been properly installed. Checks shall be made for such items in conformity with installation plans, continuity of piping, tightness of fittings, removal of temporary blank flanges, and accessibility of valves and controls. Devices shall be properly identified and operating instructions prominently posted.

6.2.11.9* The timing of the foam system discharge shall be measured beginning at the time of system actuation.

6.2.12 Final Approval. The installing company shall furnish a written statement that the work has been completed in accordance with 6.2.1 and tested in accordance with the provisions of 6.2.11.

6.2.13 Conversion of Existing Systems. In converting one type of system to another, all provisions of this chapter pertaining to new systems shall apply.

6.2.13.1 If water supplies are greater than necessary, the uniform discharge requirement of 6.2.2.6 shall be permitted to be waived if the required minimum discharge rate is available in all areas.

6.2.13.2 Where existing systems are designed with a discharge density higher than the minimum required discharge

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density [6.5 L/min/m^2 (0.16 gpm/ft^2)], a proportionate reduction in the time of discharge shall be permitted but shall not be less than 7 minutes.

6.2.13.3 Converted systems shall be tested in accordance with 6.2.11.

6.3 Wheeled and Portable Extinguishers.

6.3.1 Wheeled and portable extinguishers shall be provided in accordance with NFPA 10.

6.3.2 In aircraft storage and servicing areas, the distribution of such devices shall be in accordance with the extra hazard classification outlined in NFPA 10.

6.3.3 The distribution of extinguishers in other areas of aircraft hangars shall be in accordance with light, ordinary, or extra hazard occupancy based on an analysis of each such room or area following the requirements of NFPA 10.

6.4* Protection System Alarms. In addition to local alarm service, alarms shall be transmitted to a constantly attended location.

Chapter 7 Protection of Group II Aircraft Hangars

7.1 General.

7.1.1 The protection of aircraft storage and servicing areas of Group II aircraft hangars, other than those housing unfueled aircraft, shall be in accordance with any one of the following:

(1) The provisions of Chapter 6

Exception: Where foam–water deluge systems utilizing air-aspirating discharge devices are installed for the protection of Group II aircraft hangars, the discharge rate specified in 6.2.2.12 of this standard shall be permitted to be reduced to a minimum of 6.5 L/min/m^2 (0.16 gpm/ft^2) of floor area.

(2) A combination of automatic sprinkler protection in accordance with Section 7.2 and an automatic, low-level, low-expansion foam system in accordance with Sections 7.3 and 7.4
(3) A combination of automatic sprinkler protection in accordance with Section 7.2 and an automatic, high-expansion foam system in accordance with Sections 7.3 and 7.5
(4) A closed-head foam–water sprinkler system in accordance with Section 7.6

7.1.2 Group II aircraft hangar storage and service areas housing unfueled aircraft shall be provided with automatic sprinkler protection as specified in Sections 7.2 and 7.8.

7.1.3 Automatic closed-head sprinkler protection shall be provided inside separate shop, office, and storage areas located inside aircraft maintenance and servicing areas. The design shall be in accordance with hazard classifications specified in NFPA 13.

7.1.4 In addition to the provision for sprinkler and foam extinguishing systems as required by this chapter, protection as required by 6.2.9 and Sections 6.3 and 6.4 also shall be provided.

7.2 Closed-Head Water Sprinkler System for Aircraft Storage and Servicing Areas.

7.2.1* Sprinkler systems shall be either wet pipe or preaction, designed and installed in accordance with the applicable sections of NFPA 13 and the provisions of this chapter.

7.2.2 Sprinkler piping shall be hydraulically sized in accordance with NFPA 13.

7.2.3 Sprinkler spacing shall be as specified in 6.2.2.3.

7.2.4 Where open hangar doors result in interference with the distribution of water from the hangar sprinkler systems, additional sprinklers shall be provided to ensure effective floor coverage.

7.2.5 The design density of water from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm/ft^2) over any 464.5 m^2 (5000 ft^2) area, including the hydraulically most demanding area as defined in NFPA 13.

7.2.6 Sprinklers shall be nominal K-5.6 or K-8.0 sprinklers.

7.2.7 Sprinklers shall have a temperature rating of 162°C to 190°C (325°F to 375°F).

7.2.8 Sprinkler systems shall be flushed and tested in accordance with NFPA 13.

7.3* Foam Concentrate — General. The friction losses in piping carrying foam concentrate shall be calculated using the Darcy formula, also known as the Fanning formula.

7.3.1 The foam concentrate supplied with the system shall be listed for use with the distribution equipment.

7.3.2 There shall be a reserve of foam concentrate of a compatible type directly connected to the system. The reserve supply shall be in the same quantity as the main supply. To prevent accidental depletion of this reserve supply, it shall be available to the system only by intentional manual operation.

7.3.3 Foam Concentrate Pumps.

7.3.3.1 Foam concentrate pump installations shall comply with the applicable provisions of NFPA 20, except as modified by this standard.

7.3.3.2 Where foam concentrate is introduced into the water stream by pumping, the total foam concentrate pumping capacity shall be such that the maximum flows and pressures can be met with the largest foam concentrate pump out of service. The reserve pump(s) shall be arranged to operate only upon failure of the primary pump(s).

7.3.3.3 Piping shall be arranged so that maximum foam concentrate demand can be supplied by any foam concentrate pump from either primary or reserve foam concentrate tanks.

7.3.3.4 Foam concentrate pumps shall be provided with means of pressure relief from the pump discharge to prevent excessive pressure and temperature. Discharge from the relief valve shall be piped back to the foam concentrate storage tank. Connection to the suction piping shall not be permitted.

7.3.3.5 The pressure-regulating valve shall not be considered as the pressure relief valve. Foam concentrate pumps shall be started automatically by either a pressure drop in the foam concentrate piping system or a signal from the detection system control panel.

7.3.3.6 A pressure maintenance pump shall be provided to maintain pressure in the foam concentrate piping system where foam concentrate lines to the protective system injection points are run underground or where they run aboveground for more than 15 m (50 ft).

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7.3.3.7 Once started, foam concentrate pumps shall be arranged to run continuously until stopped manually. There shall be an audible "pump running" alarm in a constantly attended location.

7.3.3.8 Power supply for the drivers of foam concentrate pumps shall be installed in accordance with NFPA 20 and NFPA 70. Power supplies shall be arranged such that disconnecting power to the protected facility during a fire shall not disconnect the power supply to the foam concentrate pump feeder circuit.

7.3.3.9 Controllers for foam concentrate pumps shall be as follows:

(1) For electric-drive foam concentrate pumps greater than 30 horsepower, a listed fire pump controller shall be used.
(2) For electric-drive foam concentrate pumps greater than 15 horsepower but not exceeding 30 horsepower, a listed fire pump controller or listed limited service controller shall be used.
(3) For electric foam concentrate pumps less than 15 horsepower, a listed limited service controller shall be used.
(4) For diesel engine–drive foam concentrate pumps, a listed fire pump controller shall be used.

7.3.4 The control valves, foam–liquid concentrate storage, injection system, and foam concentrate pump shall be located outside aircraft storage and servicing areas. The environmental conditions shall be suitable for the particular agent involved.

7.3.5 Plans and specifications for closed-head foam–water sprinkler systems shall provide the information required by 6.2.1 of this standard and NFPA 16. Plans and specifications for other foam extinguishing systems shall provide the information required by 6.2.1.

7.3.6 Acceptance Tests.

7.3.6.1 Acceptance tests for closed-head foam–water sprinkler systems shall be performed in accordance with NFPA 16.

7.3.6.2 Acceptance tests for foam extinguishing systems shall be performed in accordance with 6.2.11.1, 6.2.11.2, 6.2.11.6, and 6.2.11.8.

7.3.6.2.1 The systems shall be subjected to flow tests with foam flowing from the maximum number of foam distributors expected to operate, in order to ensure that the hangar is protected in conformance with the design specifications and to determine if the flow pressures, agent discharge capacity, foam coverage, percentage of concentration, and other operating characteristics are satisfactory.

7.3.6.2.1.1 A flow test shall be performed with only the foam system operating.

7.3.6.2.1.2 A flow test shall be performed with the foam system operating at the design pressure with the sprinkler system and hose demand.

7.3.6.3* The timing of foam system discharge shall be measured beginning at the time of system actuation.

7.3.7 The installing company shall furnish a written statement to the effect that the work has been completed in accordance with approved plans and specifications and tested in accordance with the provisions of 7.3.6.

7.4* Low-Expansion Foam System.

7.4.1 Foam systems shall be of the fixed type and shall be designed and installed in accordance with the requirements for fixed-type systems in NFPA 11.

7.4.2 The minimum application rate of foam solution shall be 6.5 L/min/m^2 (0.16 gpm/ft^2) where protein-based or fluoroprotein-based concentrate is used. Where AFFF concentrate is used, the minimum application rate of foam solution shall be 4.1 L/min/m^2 (0.10 gpm/ft^2).

7.4.3* The discharge rate of the system shall be based on the rate of application multiplied by the entire aircraft storage and servicing floor area.

7.4.4 The foam system shall use low-level monitor-type discharge nozzles, with individual manual shutoff valves for each nozzle. The discharge nozzles shall be arranged to achieve initial foam coverage in the expected aircraft parking area.

7.4.5* The quantity of foam concentrate shall be sufficient for a 10-minute discharge at the water flow rate based on the supply calculation method.

7.4.6 The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and service area. The design objective shall be to achieve coverage of the entire aircraft storage and servicing area to within 1.5 m (5 ft) of the perimeter walls and doors within 3 minutes of system actuation.

7.5 High-Expansion Foam System.

7.5.1 High-expansion foam systems shall be designed and installed in accordance with the requirements for local application systems of NFPA 11A.

7.5.2 The high-expansion foam generators shall be arranged to achieve initial foam coverage in the anticipated aircraft parking area.

7.5.3 The effective application rate shall be a minimum of 0.9 m^3/min/m^2 (3 ft^3/min/ft^2).

7.5.4 The discharge rate of the system shall be based on the application rate multiplied by the entire aircraft storage and servicing floor area. The application total discharge rate shall include the sprinkler breakdown factor specified in 2.3.5.2(b) of NFPA 11A.

7.5.5 Foam generators shall be supplied with air from outside the aircraft storage and servicing area. Roof vents shall be located to avoid recirculation of combustion products into the air inlets of the foam generators.

7.5.6 Foam generators shall be powered by reliable water-driven or electric motors. Electric power reliability for both foam generators and foam concentrate pumps shall be consistent with electric fire pump requirements specified in Chapters 6 and 7 of NFPA 20.

7.5.7 The quantity of foam concentrate shall be sufficient to operate the system at the required discharge rate as determined in 7.5.4 for a period of at least 12 minutes.

7.5.8* The timing of the foam system discharge shall be measured beginning at the time of system actuation.

7.6 Closed-Head Foam–Water Sprinkler System.

7.6.1 Closed-head foam–water sprinkler systems shall be designed and installed in accordance with NFPA 16.

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7.6.1.1 AFFF shall be used.

7.6.2 The minimum discharge density shall be 6.5 L/min/m^2 (0.16 gpm/ft^2) of foam solution over the entire storage and service area.

7.6.3 Sprinkler spacing shall not exceed 9.3 m^2 (100 ft^2) as projected on the floor. The maximum distance between sprinklers either on branch lines or between branch lines shall be 3.7 m (12 ft).

7.6.4 In aircraft storage and servicing areas, the maximum projected floor area under an individual sprinkler system shall not exceed 1393 m^2 (15,000 ft^2).

7.6.4.1 Each individual system shall have its own foam concentrate proportioner.

7.6.5 Sprinklers shall have a temperature rating of 79.4°C to 107.2°C (175°F to 225°F).

7.6.6 Foam concentrate supply shall be in accordance with 6.2.6.

7.6.7* Branch lines shall be provided with provisions for periodic flushing.

7.6.7.1 Drains shall be a minimum of 25.4 mm (1 in.) in size.

7.7 Detection and Actuation Systems.

7.7.1 Detectors for actuating high- or low-expansion foam systems and for actuating preaction sprinkler systems shall be rate-of-rise, fixed-temperature, or rate-compensation type.

7.7.2 These detectors shall be installed in accordance with *NFPA 72.*

7.7.3 Detection systems shall be provided with supervision as required by *NFPA 72.*

7.7.4 Manual actuation stations shall be located so that each system can be individually operated from both inside and outside the aircraft storage and servicing area. The manual stations shall be installed so that they are unobstructed, readily accessible, and located in the normal paths of exit from the area.

7.8* Water Supply.

7.8.1 The total water supply shall be sufficient to satisfy the combination of systems and hose stations as described in 7.1.1(2), 7.1.1(3), and 7.1.3 for durations as specified in this section.

7.8.2 The water supply for closed-head water sprinkler systems in aircraft storage and servicing areas shall meet one of the following:

(1) In aircraft storage and servicing areas housing other than unfueled aircraft, the water supply shall have a minimum duration of 30 minutes at the rate specified in 7.2.5.
(2) In aircraft storage and servicing areas housing unfueled aircraft, the water supply shall have a minimum duration of 60 minutes at the rate specified in 7.2.5.

7.8.3 The water supply for low-expansion foam systems shall be capable of furnishing water at the rate specified in 7.4.2 for a period of time at least equal to twice the period of time used to calculate the quantity of foam liquid concentrate in 7.4.5. Water shall be suitable for the production of foam.

7.8.4 The water supply for high-expansion foam systems shall be capable of furnishing water at the rate specified in 7.5.3 for a minimum period of 24 minutes. Water shall be suitable for the production of foam.

7.8.5 The water supply for closed-head foam–water sprinkler systems shall have a minimum duration of 30 minutes at the rate specified in 7.6.2.

7.8.6 The water supply for hose stations shall be capable of satisfying the requirements of 6.2.9 of this standard, in addition to those requirements specified in 7.8.2 and either 7.8.3 or 7.8.4. The demand shall be calculated at the point where supply piping for the hose stations connects to the system piping or fire protection underground.

7.8.7 Where the water supply for the systems also serves as a supply for exterior hose streams, a hose stream allowance of 1893 L/min (500 gpm) shall be included in the water supply hydraulic calculations. Calculations for hose stream shall be in accordance with NFPA 13.

7.8.8 Where provided, fire pumps and suction reservoirs shall be designed and installed in accordance with 6.2.10.7 and 6.2.10.8.

Chapter 8 Group III Aircraft Hangars

8.1 Construction.

8.1.1* Group III hangars shall be constructed of any of the types of construction specified in NFPA 220.

8.1.2 Group III hangars shall be limited to one story. Where a Group III hangar as defined in 4.1.3 and 4.1.4 exceeds one story, the hangar shall be designated as a Group II hangar.

8.1.3 The surface of the grade floor of aircraft storage and servicing areas, regardless of type of hangar construction, shall be noncombustible and above the grade of the approach or apron at the entrance to the hangar.

8.1.4 Hangar aprons shall slope away from the level of the hangar floors to prevent liquid on the apron surfaces from flowing into the hangars.

8.1.5 In hangar building clusters and in row hangars, a minimum of 15 cm (6 in.) high curbing shall be provided between each aircraft space to prevent the flow of liquid from one space to adjacent spaces.

8.1.5.1 Open-bay hangars capable of housing multiple aircraft shall be provided with floor drainage in accordance with Section 5.11.

8.1.6 Roof coverings shall be listed as Class C or better, where tested in accordance with NFPA 256.

8.1.7 Exposed interior insulation attached to walls and roofs in an aircraft storage or servicing area of a hangar shall comply with the special provisions for aircraft storage hangars, interior wall and ceiling finish criteria of NFPA *101.*

8.2 Separation and Internal Subdivisions.

8.2.1 For single hangar buildings, the clear space distances specified in Table 8.2.1 shall be maintained on all sides of the single hangar. Where mixed types of construction are involved, the less fire-resistant type of construction shall be used to determine clear space required. Where the minimum clear spaces specified in Table 8.2.1 are not met, the buildings shall be considered a hangar building cluster.

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Table 8.2.1 Clear Space Distances for Single Hangar Buildings

Type of Construction	Minimum Separation Required	
	m	ft
Type I (443) and (332)	15	50
Type II (222)	15	50
Type II (111), Type III (211), and Type IV (2HH)	15	50
Type II (000)	15	50
Type III (200)	15	50
Type V (111) and (000)	23	75

8.2.1.1 Where single hangar buildings adjoin each other and each has fire walls with a minimum rating of at least 2 hours, located so that fire areas shall not exceed the maximum areas specified in Table 4.1.3, no minimum separation distance shall be required. These buildings shall not be considered a hangar building cluster.

8.2.2 Row hangars shall be divided by solid partitions having a fire resistance equivalent to that of the exterior walls or roof, whichever is greater, so that no more than three aircraft spaces shall be within an enclosed area.

8.2.3 Partitions and ceilings separating aircraft storage and servicing areas from other areas, such as shops, offices, and parts storage areas, shall have at least a 1-hour fire resistance rating with openings protected by listed fire doors having a fire resistance rating of at least 45 minutes.

8.3 Hangar Building Clusters.

8.3.1 In hangar building clusters, Group III hangars within a cluster shall be limited in total area for the specific types of construction in accordance with Table 8.3.1. Where mixed types of construction are involved, the less fire-resistant type of construction shall be used to determine the maximum allowable area in accordance with the table.

Table 8.3.1 Maximum Fire Areas for Hangar Building Clusters

Types of Construction	Maximum Total Fire Area	
	m^2	ft^2
Type I (443) and (332)	5,574	60,000
Type II (222)	3,716	40,000
Type II (111), Type III (211), and Type IV (2HH)	2,787	30,000
Type II (000)	2,230	24,000
Type III (200)	2,230	24,000
Type V (111)	1,486	16,000
Type V (000)	929	10,000

8.3.2 Where the total area of all Group III hangars in a cluster exceeds that specified in Table 8.3.1, selected buildings in the hangar cluster shall be considered as Group II hangars and protected in accordance with Chapter 7 of this standard. These buildings shall be selected such that the total area of the unprotected Group III hangar buildings in the hangar cluster is below the maximum area allowed by Table 8.3.1 for the less fire-resistant type of construction.

8.3.3 For hangar building clusters, the clear space distances specified in Table 8.3.3 shall be maintained on all sides of the hangar building clusters. Where mixed types of construction are involved, a less fire-resistant type of construction shall be used.

Table 8.3.3 Clear Space Distances for Hangar Building Clusters

Type of Construction	Minimum Separation Required	
	m	ft
Type I (433) and (332)	23	75
Type II (222)	23	75
Type IV (2HH)	23	75
Type II (111) and Type III (211)	30	100
Type II (000)	30	100
Type III (200)	30	100
Type V (111) and (000)	38	125

8.4 Heating and Ventilating.

8.4.1 Heating, ventilation, and air-conditioning equipment shall be installed, as applicable, in accordance with NFPA 90A, NFPA 31, and NFPA 54, except as hereinafter specifically provided.

8.4.2 No heating, ventilation, and air-conditioning equipment employing an open flame or glowing element shall be installed in aircraft storage and servicing areas or sections communicating therewith, except as provided for in 8.4.5.

8.4.3 Hangar heating plants that are fired with gas, liquid, or solid fuels not covered under 8.4.5, and that are not located in a detached building shall be located in a room separated from other parts of the hangar by construction having at least a 1-hour fire resistance rating.

8.4.3.1 This separated room shall not be used for any other hazardous purpose or combustible storage and shall have no direct access from the aircraft storage or servicing area.

8.4.3.2 Openings in the walls of such rooms communicating with other portions of the hangar shall be restricted to those necessary for ducts or pipes.

8.4.3.3 Penetrations of the 1-hour fire resistance rated enclosure shall be firestopped with an approved material properly installed and capable of maintaining the required fire resistance rating for the enclosure.

8.4.3.4 Each such duct shall be protected with a listed automatic fire damper or door.

8.4.3.5 All air for combustion purposes entering such separated rooms shall be drawn from outside the building.

8.4.4* Heating, ventilating, and air-conditioning plants employing recirculation of air within aircraft storage and servicing areas shall have return air openings not less than 3 m (10 ft) above the floor. Supply air openings shall not be in-

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stalled in the floor and shall be at least 152 mm (6 in.) from the floor measured to the bottom of the opening.

8.4.4.1 Where automatic fire protection systems are installed in aircraft storage and servicing areas, fans for furnace heating systems shall be arranged to shut down automatically by operation of the interior automatic fire protection system. One or more manual fan shutoff switches shall be provided. Shutoff switches shall be accessible and clearly placarded.

8.4.5 Suspended or Elevated Heaters.

8.4.5.1 Listed electric, gas, or oil heaters shall be permitted to be used if installed as specified in 8.4.5.2 through 8.4.5.4.

8.4.5.2 In aircraft storage and servicing areas, heaters shall be installed at least 3 m (10 ft) above the upper surface of wings or the upper surface of the engine enclosures of the highest aircraft that can be housed in the hangar. The measurement shall be made from the wing or engine enclosure, whichever is higher from the floor, to the bottom of the heater.

8.4.5.3 In shops, offices, and other sections of aircraft hangars communicating with aircraft storage or servicing areas, the bottom of the heaters shall be installed not less than 2.4 m (8 ft) above the floor.

8.4.5.4 Suspended or elevated heaters shall be located in all spaces of aircraft hangars so that they shall not be subject to injury by aircraft, cranes, movable scaffolding, or other objects. Provision shall be made to ensure accessibility to suspended heaters for recurrent maintenance purposes.

8.4.6 Where a mechanical ventilating system is employed in hangars or shops, the ventilating system shall be installed in accordance with NFPA 90A and in accordance with the applicable provisions of Section 8.4.

8.4.7 Where blower and exhaust systems are installed for vapor removal, the systems shall be installed in accordance with NFPA 91.

8.5 Lighting and Electrical Systems.

8.5.1 Artificial lighting shall be restricted to electric lighting.

8.5.2* Electrical services shall be installed in compliance with the provisions for aircraft hangars contained in Article 513 of NFPA 70.

8.6 Lightning Protection. Where provided, lightning protection shall be installed in accordance with NFPA 780.

8.7 Grounding Facilities for Static Electricity.

8.7.1* Grounding facilities shall be provided for removal and control of static electrical accumulations on aircraft while aircraft are stored or are undergoing servicing in a hangar.

8.7.2 An adequate number of floor-grounding receptacles shall be provided. The receptacles shall be either grounded through individual driven electrodes or electrically bonded together in a grid system and the entire system grounded to underground metal piping or driven electrodes. Where driven electrodes are used, they shall consist of 15.9 mm (⅝ in.) diameter or larger metal rods driven at least 1.5 m (5 ft) into the ground. Floor-grounding receptacles shall be designed to minimize the tripping hazard.

8.7.3* Grounding wires shall be bare and of a gauge that will be satisfactorily durable to withstand mechanical strains and usage.

8.8 Exit and Access Requirements.

8.8.1 Means of egress from the aircraft hangar shall comply with NFPA *101*.

8.8.1.1 Egress doors for personnel who do not require the opening of doors accommodating aircraft shall be provided in each partitioned space. Intervals between doors shall not exceed 45 m (150 ft) on all exterior walls or 30 m (100 ft) along interior walls.

8.8.2 Aisles and clear space shall be maintained to ensure access to sprinkler control valves, where provided, as well as standpipe hose, fire extinguishers, and similar equipment.

8.9 Fire Protection for Group III Hangars.

8.9.1* Where hazardous operations, including fuel transfer, welding, torch cutting, torch soldering, doping, and spray painting, are performed in any Group III hangar, the Group III hangar shall be protected with the fire protection specified in Chapter 7 and also shall meet the requirements specified in 5.4.2.

8.9.2 Portable fire extinguishers shall be provided in accordance with NFPA 10. Where portable extinguishers are locked up to preclude the possibility of theft, each tenant and aircraft owner shall be provided with a key for the locks.

8.9.2.1 In aircraft storage and servicing areas, the distribution of portable fire extinguishers shall be in accordance with extra hazard classification outlined in NFPA 10.

8.9.2.2 The distribution of extinguishers in other areas of aircraft hangars shall be in accordance with light, ordinary, or extra hazard occupancy based on an analysis of each room or area following the requirements of NFPA 10.

Chapter 9 Group IV Aircraft Hangars

9.1* Construction.

9.1.1 When membrane-covered rigid-steel-frame structures are used for the construction of aircraft hangars, they shall be constructed in accordance with Chapter 9.

9.1.2 The hangar shall be limited to one story.

9.1.3 The hangar shall be limited to a single hangar fire area.

9.1.4 Where provided, roof drains shall be equipped with electrical elements to protect against ice buildup, which would prevent the drains from functioning. Such heating elements shall be served by on-site standby electrical power in addition to the normal public service. In lieu of such heating elements, any other approved methods that protect against ice accumulation shall be permitted.

9.1.5 Membrane Materials.

9.1.5.1 Testing of membrane materials for compliance with the use of the categories of noncombustible and limited-combustible materials in accordance with 9.1.5 shall be performed on weathered membrane material.

9.1.5.2 Flame spread of all membrane materials exposed within the structure shall be Class A as defined in NFPA *101*.

9.1.5.3 Flame Resistance. All membrane structure fabric shall meet the requirements of both the small-scale and large-scale tests contained in NFPA 701.

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9.1.5.4 Where required by the authority having jurisdiction, confirmatory field tests shall be conducted using test specimens from the original material, which shall have been affixed at the time of manufacture to the exterior of the structure.

9.1.5.5 Material loading and strength shall be based on physical properties of the materials verified and certified by an approved testing laboratory.

9.1.5.6 The membrane roof for structures in climates subject to freezing temperatures and ice buildup shall be composed of two layers with an air space between the two layers through which heated air can be moved to guard against ice accumulation. In lieu of such construction, any other approved methods that protect against ice accumulations shall be permitted.

9.2 Internal Separations.

9.2.1 Mezzanines, tool rooms, and other enclosures within aircraft storage and servicing areas shall be constructed of noncombustible material or limited-combustible material as defined in NFPA 220 in all membrane-covered rigid-steel-frame-structure hangars.

9.2.2 Partitions and ceilings separating aircraft storage and servicing areas from all other areas, shops, offices, and parts storage areas shall have at least a 1-hour fire resistance rating with openings protected by listed fire doors or shutters having a minimum fire resistance rating of 45 minutes.

9.2.3 Where a storage and servicing area has an attached, adjoining, or contiguous structure, such as a lean-to, shop, office, or parts storage area, the wall common to both areas shall have at least a 1-hour fire resistance rating, with openings protected by listed fire doors having a minimum fire resistance rating of 45 minutes and actuated from both sides of the wall.

9.3 Clear Space Distance Around Hangars. Precautions shall be taken to ensure ready access to membrane-covered rigid-steel-frame-structure hangars from all sides. Adequate separation shall be provided to reduce fire exposure between buildings. The minimum separation shall be 23 m (75 ft).

9.4 Aprons and Floors.

9.4.1 The surface of the grade floor of aircraft storage and servicing areas shall be noncombustible and above the grade of the approach or apron at the entrance to the hangar.

9.4.2 Hangar aprons shall slope away from the level of the hangar floors to prevent liquid on the apron surfaces from flowing into the hangars.

9.5 Doors.

9.5.1 In membrane-covered rigid-steel-frame-structure hangars with a hangar fire area greater than 1115 m^2 (12,000 ft^2), hangar doors that accommodate aircraft shall be of noncombustible or limited-combustible construction.

9.5.2 The power source for hangar doors shall operate on independent circuits and shall not be de-energized when the main disconnect switches for general hangar power are shut off.

9.5.3 Vertical traveling doors shall be counterbalanced, and horizontal slide or accordion-type doors shall be arranged so that manual or auxiliary operation by means of winches or tractors, for example, is feasible.

9.5.4 In an area where freezing temperatures can occur, door tracks of the bottom edges of doors shall be protected by heating coils or equivalent means to prevent ice formation that might prevent or delay operation.

9.6 Curtains. Where curtains are used to enclose a work area, they shall be of a listed flame-retardant type.

9.7 Landing Gear Pits, Ducts, and Tunnels.

9.7.1 Landing gear pits, ducts, and tunnels that are located below floor level in membrane-covered rigid-steel-frame-structure hangars shall be designed on the premise that flammable liquids and vapors will be present at all times. Materials and equipment shall be impervious to liquids and shall be fire resistant or noncombustible.

9.7.2 Electrical equipment for all landing gear pits, ducts, and tunnels that are located below hangar floor level shall be suitable for use in Class I, Division 1, Group D hazardous locations in compliance with Article 501 of NFPA 70.

9.7.3 All landing gear pits, ducts, and tunnels that are located below hangar floor level shall be provided with a positive mechanical exhaust ventilation system capable of providing a minimum rate of five air changes per hour during normal operations and be designed to discharge externally to the hangar.

9.7.4 Upon the detection of flammable vapors, the ventilation system shall be capable of providing a minimum ventilation rate of 30 air changes per hour for the landing gear pit and all associated ducts or tunnels.

9.7.5 The ventilation system shall be controlled by an approved continuous-reading combustible gas–analyzing system that is arranged to operate the ventilation system at the rate specified in 9.7.4 automatically upon detection of a specified flammable vapor concentration that is below the LFL. The detection system shall have sensors located throughout all ducts and tunnels.

9.7.6 Because entry of fuel, oil, and water into landing gear pits is inevitable, drainage or pumping facilities shall be provided. Water-trapped vapor seals and appropriate separator fuel traps shall be provided. Where automatic pumping facilities are necessary, they shall be suitable for use with aviation fuel and water. The drainage shall be fully enclosed pipe runs if drainage is routed through ventilation or access tunnels to external discharge points.

9.7.7 Explosion protection shall be provided in landing gear pits and communicating ducts and tunnel areas in the form of pressure relief venting or by a listed explosion prevention system installed in accordance with NFPA 69.

9.7.8 An approved fire protection system shall be installed to protect each pit unless the hangar fire protection required by Section 9.14 is adequate to protect each pit.

9.8 Exposed Interior Insulation. Exposed interior insulation attached to walls and roofs in the aircraft storage and servicing area of a hangar shall comply with the requirements of the special provisions for aircraft storage hangars, interior wall and ceiling finish criteria of NFPA *101*.

9.9 Drainage of Aprons and Hangar Floors. The drainage of aprons and hangar floors of hangars with a hangar fire area greater than 1115 m^2 (12,000 ft^2) shall be as specified in Section 5.11.

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9.10 Heating and Ventilating. Heating, ventilating, and air-conditioning equipment of membrane-covered rigid-steel-frame-structure hangars shall be installed, as applicable, in accordance with Section 5.12.

9.11 Lighting and Electrical Systems.

9.11.1 Artificial lighting shall be restricted to electric lighting.

9.11.2 Electrical services shall be installed in compliance with the provisions for aircraft hangars contained in Article 513 of NFPA 70.

9.11.3 In hangars with aircraft storage and servicing areas greater than 1115 m^2 (12,000 ft^2), housing other than unfueled aircraft, main distribution panels, metering equipment, and similar electrical equipment shall be located in a room separated from the aircraft storage and servicing area by a partition having at least a 1-hour fire resistance rating. The partition shall not be penetrated except by electrical raceways, which shall be protected by approved sealing methods maintaining the same fire resistance rating as the partition.

9.12 Grounding Facilities for Static Electricity.

9.12.1 Membrane-covered rigid-steel-frame-structure hangars housing other than unfilled aircraft shall be provided with grounding facilities for the removal and control of static electrical accumulations on aircraft while aircraft are stored or undergoing servicing in a hangar.

9.12.2 An adequate number of floor-grounding receptacles shall be provided. The receptacles shall be either grounded through individual driven electrodes or electrically bonded together in a grid system and the entire system grounded to underground metal piping, such as cold water or sprinkler piping, or driven electrodes. Where driven electrodes are used, they shall consist of 15.9 mm (⅝ in.) diameter or larger metal rods driven at least 1.5 m (5 ft) into the ground. Floor-grounding receptacles shall be designed to minimize the tripping hazard.

9.12.3* Grounding wires shall be bare and of a gauge that is satisfactorily durable to withstand mechanical strains and usage.

9.13 Exit and Access Requirements.

9.13.1 Mean of egress from membrane-covered rigid-steel-frame-structure hangars shall comply with NFPA *101*.

9.13.1.1 Egress doors for personnel that do not require the opening of doors accommodating aircraft shall be provided in each partitioned space. Intervals between doors shall not exceed 45 m (150 ft) on all exterior walls or 30 m (100 ft) along interior walls.

9.13.2 Aisles and clear space shall be maintained to ensure access to sprinkler control valves, standpipe hose fire extinguishers, and similar equipment.

9.14 Fire Protection for Membrane-Covered Rigid-Steel-Frame-Structure Hangars.

9.14.1 The protection of aircraft storage and servicing areas for membrane-covered rigid-steel-frame-structure hangars having a hangar fire area greater than 1115 m^2 (12,000 ft^2) and housing fueled aircraft shall be in accordance with any of the following:

(1) A low-expansion foam system as specified in 9.14.7.4
(2) A high-expansion foam system as specified in 9.14.7.5

9.14.2 The protection of aircraft storage and servicing areas for membrane-covered rigid-steel-frame-structure hangars having a hangar fire area greater than 1115 m^2 (12,000 ft^2) and housing unfueled aircraft shall be in accordance with any of the following:

(1) A low-expansion foam system as specified in 9.14.7.4
(2) A high-expansion foam system as specified in 9.14.7.5
(3) Automatic sprinkler protection that complies with the following and Section 7.8 (for water supply):
   (a) Closed-head water sprinkler system for aircraft storage and servicing areas. Sprinkler systems shall be either wet pipe or preaction, designed and installed in accordance with the applicable sections of NFPA 13 and the provisions of this chapter.
   (b) Sprinkler piping shall be hydraulically sized in accordance with NFPA 13.
   (c) Sprinkler spacing shall be as specified in 6.2.2.3.
   (d) Where open hangar doors result in interference with the distribution of water from the hangar sprinkler systems, additional sprinklers shall be provided to ensure effective floor coverage.
   (e) The design density of water from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm/ft^2) over any 464.5 m^2 (5000 ft^2) area, including the hydraulically most demanding area as defined in NFPA 13.
   (f) Sprinklers shall have a nominal orifice size of 12.7 mm (½ in.) or 13.5 mm (17⁄32 in.).
   (g) Quick-response sprinklers having a temperature rating of 79.4°C (175°F) shall be used. Quick-response sprinklers having a temperature rating of 93.3°C (200°F) or 28°C (50°F) above the highest ambient temperature shall be permitted in areas subject to high ambient temperatures.
   (h) Sprinkler systems shall be flushed and tested in accordance with NFPA 13.

9.14.3 The protection of aircraft storage and servicing areas for membrane-covered rigid-steel-frame-structure hangars having a hangar fire area less than 1115 m^2 (12,000 ft^2) and where hazardous operations, including fuel transfer, welding, torch cutting, torch soldering, doping, and spray painting, are performed shall be by an approved automatic sprinkler system in accordance with NFPA 13.

9.14.4 All mezzanines used for storage and all enclosed areas, including separate shops, offices, and storage areas, located in membrane-covered rigid-steel-frame-structure hangars shall be protected by an approved automatic sprinkler system in accordance with NFPA 13.

9.14.5 Protection Systems.

9.14.5.1 Aircraft storage and servicing areas shall be protected with listed protection systems.

9.14.5.2 Each system shall be designed to cover the entire floor area of the hangar. The design objective shall be to achieve control of the fire in the protected area in 30 seconds of system actuation and extinguishment of the fire within 60 seconds.

9.14.5.3 Each protection system shall be designed, installed, and maintained in accordance with NFPA 11 or NFPA 11A.

9.14.6 Plans and Specifications.

9.14.6.1 Before systems are installed, complete specifications and working plans shall be drawn to scale showing all essential details, and plans shall be easily reproducible to provide necessary copies.

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9.14.6.2 Information supplied in these plans and specifications shall include the following:

(1) Design purpose of the systems
(2) Discharge densities and the period of discharge
(3) Hydraulic calculations
(4) Details of tests of the available water supply
(5) Details of proposed water supplies
(6) Detailed layout of the piping and of the detection systems
(7) Make and type of discharge devices, operating equipment, and foam concentrate to be installed
(8) Location and spacing of discharge devices
(9) Pipe hanger and bracing locations and installation details
(10) Accurate and complete layout of the area to be protected, including drainage layout
(11) Details of any foam concentrate, its storage and injection, and other pertinent data to provide a clear explanation of the proposed design
(12) Location and spacing of supplementary or low-level agent distributors, showing the area of coverage
(13) Installation layout of the actuation systems
(14) Detailed layout of water supply piping, agent storage, pumping and piping, power sources, and location and details of mechanical foam-liquid concentrate injection equipment

9.14.7 Low-Level Foam Protection Systems.

9.14.7.1 Hangars protected in accordance with 6.1.1(1) or 6.1.1(2) shall be protected with a listed low-level foam protection system.

9.14.7.2 Each low-level foam protection system shall be designed, installed, and maintained in accordance with NFPA 11 or NFPA 11A.

9.14.7.3 The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and servicing area. The design objective shall be to achieve coverage of the entire aircraft storage and servicing area within 3 minutes of system actuation.

9.14.7.4 Low-Level Low-Expansion Foam Systems. Foam systems shall be of the fixed type and shall be designed and installed in accordance with the requirements for fixed-type systems in NFPA 11.

9.14.7.4.1 Where AFFF concentrate is used, the minimum application rate of foam solution shall be 4.1 L/min/m^2 (0.10 gpm/ft^2). The minimum application rate of foam solution shall be 6.5 L/min/m^2 (0.16 gpm/ft^2) where protein-based or fluoroprotein-based concentrate is used.

9.14.7.4.2* The discharge rate of the system shall be based on the rate of application multiplied by the entire aircraft storage and servicing floor area.

9.14.7.4.3 The foam system shall use low-level discharge nozzles. Where monitor nozzles are used, they shall be provided with individual manual shutoff valves for each nozzle. The discharge nozzles shall be arranged to achieve initial foam coverage in the expected aircraft parking area.

9.14.7.4.4 Nozzles shall be located and installed so that aircraft positioning and workstand placement will not necessitate removal or repositioning of nozzles. All nozzle settings shall be marked and permanently secured in position after installation and acceptance testing.

9.14.7.4.5 Electric power reliability for oscillating nozzles shall be in accordance with electric fire pump requirements of NFPA 20.

9.14.7.5 Low-Level High-Expansion Foam Systems.

9.14.7.5.1 Low-level high-expansion foam systems shall be designed and installed in accordance with the requirements for local application systems of NFPA 11A.

9.14.7.5.2 The effective application rate shall be a minimum of 0.9 $m^3/min/m^2$ (3 $ft^3/min/ft^2$).

9.14.7.5.3 The discharge rate of the system shall be based on the application rate multiplied by the entire aircraft storage and servicing floor area. The application total discharge rate shall include the sprinkler breakdown factor specified in 2.3.5.2(b) of NFPA 11A.

9.14.7.5.4 The high-expansion foam generators shall be arranged to achieve initial foam coverage in the expected aircraft parking area.

9.14.7.5.5 Foam generators shall be supplied with air from outside the aircraft storage and servicing area. Roof vents shall be located to avoid recirculation of combustion products into the air inlets of the foam generators.

9.14.7.5.6 Foam generators shall be powered by reliable water-driven or electric motors. Electric power reliability for foam generators shall be consistent with electric fire pump requirements specified in Chapters 9 and 10 of NFPA 20.

9.14.8 Foam Concentrate Supply.

9.14.8.1 Where foam concentrate is introduced into the water stream by pumping, the total foam concentrate pumping capacity shall be such that the maximum pressures and flows can be met with the largest foam concentrate pump out of service.

9.14.8.2 The quantities of low-expansion foam concentrate — protein foam, fluoroprotein foam, or AFFF — shall be sufficient for a 10-minute foam discharge based on the supply calculation method.

9.14.8.3 The quantity of high-expansion foam concentrate shall be sufficient for a 12-minute discharge at the water flow rate as determined in 9.14.7.5.3.

9.14.8.4 A reserve supply of foam concentrate of compatible type for the system shall be directly connected to the system and readily available. The reserve supply shall be in the same quantity as the main supply. To prevent accidental depletion of this reserve supply, it shall be available to the system only by intentional manual operation.

9.14.8.5 Control valves, foam concentrate liquid storage tanks, concentrate pumps, controllers, and bypass balancing equipment shall be located outside the aircraft storage and servicing area.

9.14.9 Foam Concentrate Pumps.

9.14.9.1 Where foam concentrate is introduced into the water stream by pumping, the total foam concentrate pumping capacity shall be such that the maximum flows and pressures can be met with the largest foam concentrate pump out of service.

9.14.9.2 Power supply for the drivers of foam concentrate pumps shall be installed in accordance with NFPA 20 and NFPA 70. Power supplies shall be arranged such that disconnecting power to the protected facility during a fire shall not

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disconnect the power supply to the foam concentrate pump feeder circuit.

9.14.9.3 Controllers for foam concentrate pumps shall be as follows:

(1) For electric-drive foam concentrate pumps greater than 30 horsepower, a listed fire pump controller shall be used.
(2) For electric-drive foam concentrate pumps greater than 15 horsepower but not exceeding 30 horsepower, a listed fire pump controller or listed limited service controller shall be used.
(3) For electric-drive foam concentrate pumps less than 15 horsepower, a listed limited-service controller shall be used.
(4) For diesel engine–drive foam concentrate pumps, a listed fire pump controller shall be used.

9.14.9.4 Piping shall be arranged so that maximum foam concentrate demand can be supplied from either primary or reserve foam concentrate tanks.

9.14.10 Detection and Actuation System Design.

9.14.10.1 General. Actuation systems shall be provided with complete circuit supervision and shall be arranged in accordance with 9.14.15.

9.14.10.2 Foam Fire Protection Systems.

9.14.10.2.1* An automatic detection system shall be provided for actuation of these systems. Detection systems shall be installed in accordance with *NFPA 72*.

9.14.10.2.2 Manual actuation stations shall be provided for each low-expansion protection system and shall be located both inside and outside the aircraft maintenance and servicing area. Stations shall be located as close as possible to the aircraft positions to facilitate early system actuation in the event of a fire.

9.14.11 Hand Hose Systems.

9.14.11.1 Hand hose systems shall be installed in every hangar, to provide for manual fire control.

9.14.11.2 The hand hose systems shall be arranged to permit application of water or other extinguishing agents on each side and into the interior of the aircraft located in the aircraft storage and servicing area. At least two hose lines shall be considered to be operated simultaneously.

9.14.11.3 Foam–Water Hand Hose Systems.

9.14.11.3.1 Foam–water hand hose systems shall be installed in the aircraft storage and servicing areas having a hangar fire area greater than 1115 m^2 (12,000 ft^2) housing other than unfueled aircraft.

9.14.11.3.2 The systems shall conform with the applicable portions of NFPA 14 and of NFPA 11 or NFPA 11A.

9.14.11.3.3 These foam–water hand hose systems shall be supplied from a connection to the low-expansion or high-expansion foam system header or from a direct connection to the water source.

9.14.11.3.4 Each foam–water hand hose connection shall be a minimum of 38 mm (1½ in.) in size and fitted with a control valve. The hose shall be of suitable length and diameter to provide a minimum flow of 227 L/min (60 gpm) at an adequate nozzle pressure. The stream range shall be calculated based on the volume and pressures available under maximum demand conditions.

9.14.11.3.5 The hose shall be racked or reeled. Hoses shall be fitted with an approved foam-maker nozzle or a combination-type nozzle designed to permit foam application or water spray. Nozzles shall be of the shutoff type or shall have a shutoff valve at the nozzle inlet.

9.14.11.3.6 Foam-liquid concentrate shall be permitted to be supplied from either a central distribution system, separate from or a part of a foam–water system, or from stationary foam-liquid concentrate containers fitted with listed proportioning devices.

9.14.11.3.7 The minimum supply of foam-liquid concentrate shall be sufficient to provide operation of at least two hand hose lines for a period of 20 minutes at a foam solution discharge rate of 227 L/min (60 gpm) each.

9.14.11.4 Water Hand Hose Systems.

9.14.11.4.1 Water hand hose and standpipe systems shall be installed in accordance with NFPA 14 in aircraft storage and servicing areas having a hangar fire area greater than 1115 m^2 (12,000 ft^2) and housing unfueled aircraft and all shop, office, and nonaircraft storage areas in hangars, except where special hazards that require special protection exist.

9.14.11.4.2 Water hand hoses shall be fitted with listed adjustable stream pattern nozzles designed to permit straight stream or water spray application.

9.14.12 Water Supply.

9.14.12.1 The total water supply shall be sufficient to satisfy the protection systems as described in 9.14.1(1), 9.14.1(2), 9.14.2(1) through 9.14.2(3), 9.14.3, and 9.14.4 and the requirements for hose stream and other equipment as determined in 9.14.11. Water shall be available in sufficient quantity and pressure to supply the maximum number of discharge devices likely to operate simultaneously. Water shall be suitable for the production of foam.

9.14.12.2 The total water supply duration shall be for a minimum of 45 minutes.

9.14.12.3 Hand Hose Systems. The water supply for hand hose systems shall be capable of satisfying the requirements of 9.14.11. The demand shall be calculated at the point where supply piping for the hand hose systems connects to the system piping or fire protection underground.

9.14.12.4 Exterior Hose Streams. Where the water supply for the systems also serves as a supply for exterior hose streams, a hose stream allowance of 1893 L/min (500 gpm) shall be included in the water supply hydraulic calculations. Calculations for hose stream shall be in accordance with NFPA 13.

9.14.12.5 Water Reservoirs. Where a single reservoir is used for the basic water supply, such reservoir shall be divided into approximately equal sections, arranged so that at least one-half of the water supply will always be maintained in service in order to increase the reliability of the water supply. The suction line from each section shall be sized to deliver the maximum water supply requirement.

9.14.13 Fire Pumps.

9.14.13.1 Fire pumps shall be installed in accordance with NFPA 20 and in accordance with the provisions of 9.14.13.2 through 9.14.13.6.

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9.14.13.2 The total pumping capacity shall be such that maximum demand can be met with the largest fire pump out of service.

9.14.13.3 Fire pump houses and fire pump rooms shall be of fire-resistive or noncombustible construction. Where internal combustion engines used for driving fire pumps are located inside the fire pump house or fire pump room, protection shall be provided by automatic sprinklers installed in accordance with NFPA 13.

9.14.13.4 Fire pumps shall be started automatically by either a drop in water pressure or a signal from the detection control panel. Where two or more pumps are used, they shall be provided with automatic sequential starting.

9.14.13.5 Frequent operation of fire pumps shall be avoided by the installation of a small auxiliary pressure maintenance pump or other suitable means to maintain normal system pressures.

9.14.13.6 Once started, fire pumps shall be arranged to run continuously until they are stopped manually. There shall be an audible "pump running" alarm in a continuously attended area.

9.14.13.7 Flushing Underground Pipe. Underground mains and each lead-in connection shall be flushed as specified in NFPA 24.

9.14.13.8 Acceptance Tests.

9.14.13.8.1 The tests in 9.14.13.8.2 through 9.14.13.8.8 shall be performed prior to final acceptance of any fire protection system in an aircraft hangar.

9.14.13.8.2 Hydrostatic pressure tests shall be conducted on each system as specified in NFPA 11, NFPA 11A, NFPA 13, or NFPA 14, as applicable.

9.14.13.8.3 All devices and equipment installed as part of the system shall be tested.

9.14.13.8.4 The maximum number of systems expected to operate shall be simultaneously discharged with foam. This test shall be run for a length of time sufficient to stabilize discharge before test samples are taken to determine foam concentrate percentage.

9.14.13.8.5 Any proportioner not tested under the requirements of 9.14.13.8.4 shall be individually tested with foam concentrate to determine concentrate percentage.

9.14.13.8.6 Low-expansion and high-expansion foam protection systems shall be subjected to foam flow tests, with foam flowing simultaneously from the maximum number of foam nozzles or generators expected to operate, in order to ensure that the hazard is protected in conformance with the design specification and to determine whether the flow pressures, agent discharge capacity, foam coverage, percent concentration, and other operating characteristics are satisfactory.

9.14.13.8.7 Low-expansion and high-expansion foam protection systems shall be examined visually to determine that they have been properly installed. Checks shall be made for such items in conformity with installation plans, continuity of piping, tightness of fittings, removal of temporary blank flanges, and accessibility of valves and controls. Devices shall be properly identified, and operating instructions shall be prominently posted.

9.14.13.8.8* The timing of foam system discharge shall be measured beginning at the time of system actuation.

9.14.13.9 Final Approval. The installing company shall furnish a written statement that the work has been completed in accordance with 9.14.6 and tested in accordance with the provisions of 9.14.13.8.

9.14.14 Wheeled and Portable Extinguishers.

9.14.14.1 Wheeled and portable extinguishers shall be provided in accordance with NFPA 10.

9.14.14.2 In aircraft storage and servicing areas, the distribution of such devices shall be in accordance with the extra hazard classification outlined in NFPA 10.

9.14.14.3 The distribution of extinguishers in other areas of aircraft hangars shall be in accordance with light, ordinary, or extra hazard occupancy based on an analysis of each room or area following the requirements of NFPA 10.

9.14.15* Protection System Alarms. In addition to local alarm service, alarms shall be transmitted to a constantly attended location.

Chapter 10 Paint Hangars

10.1 Construction.

10.1.1 Paint hangars shall be constructed in accordance with Chapter 5 of this standard.

10.1.2 All flammable or combustible liquid storage, mixing, and application apparatus cleaning operations shall be separated from the paint hangar by a minimum 2-hour rated fire separation, with the openings protected by 1½-hour rated fire doors.

10.2 Fire Protection.

10.2.1 The protection of aircraft paint hangars housing other than unfueled aircraft shall be in accordance with either Chapter 6 or Chapter 7 of this standard, whichever is applicable.

10.2.2 The protection of an aircraft paint hangar housing unfueled aircraft shall be in accordance with the provisions of NFPA 13 for an extra hazard group 2 occupancy.

10.3 Ventilation.

10.3.1 The ventilation system in a paint hangar shall be in accordance with the ventilation provisions of NFPA 33 and 10.3.2 through 10.3.4 of this standard.

10.3.2 Ventilation shall be provided to prevent the accumulation of flammable vapors to not more than 25 percent of the LFL in the exhaust stream exiting the paint area.

10.3.3 Recirculation of a portion of the exhaust stream back into the hangar shall be permitted, provided the recirculation provisions of NFPA 33 for booths and rooms and the requirements of 10.3.3.1 and 10.3.3.2 are met.

10.3.3.1* Supply air flow shall be unidirectional and shall provide a uniform airflow across the cross-sectional area of the filters.

10.3.3.2* If the concentration of vapors in the exhaust air stream exceeds 25 percent of the LFL, the recirculation equipment shall be arranged to automatically shut down until the hazardous condition is corrected.

10.3.4 Paint or other flammable or combustible liquid application equipment shall be interlocked with the ventilation system such that the loss of supply, makeup air, or exhaust fans that reduce the supply airflow to below 75 percent of design airflow will interrupt the operation of this application equipment.

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10.4 Electrical Equipment.

10.4.1 Electrical equipment in a paint hangar shall be in accordance with Article 513 and Article 516 of NFPA 70 and 10.4.2 through 10.4.5 of this standard.

10.4.2 The area around the aircraft perimeter, extending 3 m (10 ft) horizontally and 3 m (10 ft) vertically, shall be considered a Class I, Division 1 location. All electrical wiring and equipment in this area shall comply with the applicable provisions of Article 501 of NFPA 70.

10.4.3 The area around the aircraft perimeter, extending from 3 m to 9.1 m (10 ft to 30 ft) horizontally and 3 m to 6.1 m (10 ft to 20 ft) vertically, shall be considered a Class I, Division 2 location. All electrical wiring and equipment in this area shall comply with the applicable provisions of Article 501 of NFPA 70.

10.4.4 All lighting fixtures within a paint hangar shall be totally enclosed or constructed so as to prevent the escape of sparks or hot particles.

10.4.5* In addition to the grounding requirements in Chapter 5, grounding facilities shall be provided for the paint or other flammable or combustible liquid application system and the application system operator.

10.5 Operations. Flammable or combustible liquid operations inside a paint hangar shall be in accordance with the provisions of NFPA 30 and NFPA 410.

Chapter 11 Periodic Inspection and Testing

11.1 Fire Protection Systems.

11.1.1 Inspection and testing of fire protection systems in aircraft hangars shall be performed in accordance with NFPA 25 as modified by Table 11.1.1.

11.1.2 All preprimed closed-head AFFF systems shall be drained, flushed, and reprimed annually.

11.1.3 Records of inspections, tests, and test results shall be maintained.

Table 11.1.1 Inspection and Testing of Hangar Fire Protection Systems

	Type and Frequency of Inspections and Tests					
System Components	Weekly	Monthly	Semi-annually	Annually	Quarterly	Every 5 Years
Sprinkler heads	—	—	—	V	—	—
Piping	—	—	—	V	—	D
Pipe hangers	—	—	—	V	—	—
Sprinkler alarm valve	—	V	—	—	O[1]	—
Deluge valve	—	V	—	O	—	D
Shutoff valves	—	V	—	F	—	—
Fire pumps	F[4]	—	—	D	—	—
Water reservoirs	—	V	—	—	—	—
Hose stations	—	V	—	—	—	D
Strainers	—	—	—	V	—	—
Foam concentrate	—	—	—	F[2]	—	—
Concentrate storage tanks	—	V	—	—	—	—
Concentrate pump	F[4]	—	—	O	—	D
Concentrate control valve (automatic)	—	V	—	O	—	D
Concentrate shutoff valve	—	V	—	F	—	—
Foam proportioning device	—	V	—	—	—	D
Water-powered monitor nozzle	—	V	—	D	—	—
Electric-powered manual nozzle	—	V	—	F	—	D
Water-powered high-expansion-foam (HEF) generator	—	V	—	O	—	D
Electric-powered high-expansion-foam (HEF) generator	—	V	—	F	—	D
Pneumatic detector	—	—	F	O[3]	—	—
Electric detector	—	—	F	O[3]	—	—
Optical detector	V	—	F	O[3]	—	—
Control panels	—	V	F	O	—	—
Alarm transmission (local and remote)	—	F	—	—	—	—
Tamper switch	—	—	—	—	F	—
Flow indication switch	—	—	—	O	—	—
Supervisory alarms	—	—	F	—	—	—
Manual actuation stations	—	—	F	—	—	—
Hangar floor drain system and separators	—	V	—	—	—	D
Fire doors	—	V	—	F	—	—
Gas detectors	—	V	F	—	—	—
Ventilation system in pits, tunnels, and ducts	—	—	F	—	—	—
Grounding equipment	—	—	—	—	—	F

V: Visual inspection. F: Functional test, no flow. O: Operational test with flow, no discharge. D: Operational test with actual discharge.

Notes:

[1]For the purposes of this test, the inspector's flow valve is acceptable.

[2]A sample should be sent to the manufacturer for analysis.

[3]At this time it is necessary to check that the set points are the same as the original.

[4]Churn test.

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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.1.2.1 The adequacy and usefulness of aircraft hangars depends to a large extent on the fire resistance of their construction and the fire protection provided within the buildings.

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, 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 documents in a broad manner, since 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.3.2.3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.2 Aircraft Hangar. For overall height of various transport-type aircraft, see Table A.3.3.2.

A.3.3.3 Aircraft Storage and Servicing Area. Wherever the term *storage and servicing* is used in this document, it is intended to imply that it is the area where aircraft are stored, serviced, or both.

A.3.3.12 Paint Hangar. As prescribed in NFPA 410, painting operations in maintenance and storage hangars are limited to 80 ft^2 in a 2-hour period. For purposes of this standard, this applies to the application of any flammable or combustible liquids.

Table A.3.3.2 Gross Wing Area and Overall Height for Selected Aircraft

Aircraft	Gross Wing Area		Overall Height	
	m^2	ft^2	m	ft–in.
Airbus A-380*	830.0	8920	24.1†	79–0
Antonov An-124*	628.0†	6760	21.0†	69–2
Lockheed L-500-Galaxy*	576.0†	6200	19.8†	65–1
Boeing 747*	541.1†	5825	19.4†	63–8
Airbus A-340-500, -600*	437.0†	4703	16.7†	54–11
Boeing 777*	427.8†	4605	18.5†	60–9
Ilyushin II-96*	391.6†	4215		
DC-10-20, 30*	367.7†	3958	17.7†	58–1
Airbus A-340-200, -300, A-330-200, -300*	361.6†	3892	16.7†	54–11
DC-10-10*	358.7†	3861	17.7†	58–1
Concorde*	358.2†	3856	12.2†	40–0
Boeing MD-11*	339.9†	3648	17.6†	57–9
Boeing MD-17*	353.0†	3800	16.8†	55–1
L-1011*	321.1†	3456	16.9†	55–4
Ilyushin II-76*	300.0†	3229	14.8†	48–5
Boeing 767*	283.4†	3050	15.8†	52–0
Ilyushun IL-62*	281.5†	3030	12.3†	40–6
DC-10 MD-10	272.4	2932		
DC-8-63, -73	271.9	2927		
DC-8-62, -72	271.8	2926		
DC-8-61, 71	267.8	2883		
Airbus A-300	260.0†	2799	16.5†	54–3
Airbus A-310	218.9†	2357	15.8†	51–10

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Table A.3.3.2 *Continued*

Aircraft	Gross Wing Area		Overall Height	
	m^2	ft^2	m	ft–in.
Tupolev TU-154	201.5†	2169	11.4†	37–4
Boeing 757	185.2†	1994	13.5†	44–6
Tupolev TU-204	182.4†	1963	13.9†	45–7
Boeing 727-200	157.9†	1700	10.4†	34–0
Lockheed L-100J Hercules	162.1†	1745	11.6†	38–3
Yakovlev Yak-42	150.0†	1614	9.3†	32–3
Boeing 737-600, -700, -800, -900	125.0†	1345	12.5†	43–3
Airbus A-318, A-319, A-320, A-321	122.6†	1319	11.8†	38–8
Boeing MD 80	112.3†	1209	9.0†	29–7
MD 90			9.3†	30–7
Gulfstream V	105.6†	1137	7.9†	25–10
Boeing 737-300, -400, -500	105.4†	1135	11.1†	36–6
Tupolev TU-334, TU-354	100.0†	1076	9.4†	30–9
BAC 1-11-500	95.8†	1031	7.5†	24–6
NAMC YS-11	94.8†	1020	8.9†	29–5
Fokker 100, 70	93.5†	1006	8.5†	27–10
BAC 1-11-300, -400	93.2	1003	7.5†	24–6
Boeing 717	93.0†	1001	8.8†	29–1
DC-9-30	93.0†	1001	8.4†	27–6
Boeing 737-200	91.0†	980	11.3†	37–0
Gulfstream IV	88.3†	950	7.4†	24–5
DC 9-10	86.8†	934	8.4†	27–6
BAe 146, RJX-70, -85, -100	77.3†	832	8.6†	28–3
Fokker 50, 60	70.0†	753	2.7†	27–3
Canadair RJ-700	68.6†	738	7.6†	24–10
Dash 8 Q400	63.0†	679	7.5†	24–7
ATR 72	61.0†	656	7.6†	25–1
Airtech CN-235	59.1†	636	8.2†	26–10
Saab 2000	55.7†	600	7.7†	25–4
Canadair RJ-100, -200	54.5†	587	6.2†	20–5
ATR 42	42.5†	586	7.6†	24–10
Dash 8 Q100, Q200	54.3†	585	7.5†	24–7
Embraer ERJ-135, -145	51.1†	550	6.9†	22–1
Cessna 750	48.9†	527	5.8†	18–11
Cessna 680	47.9†	516	5.5†	19–2
Saab 340	41.8†	450	6.9†	22–1
Embraer EMB-120	39.4†	424	6.3†	20–10
Bell Boeing V-22	39.5†	382	6.6†	21–9
Britten-Norman BN2	30.2†	325	4.2†	13–8
Cessna 650	28.9†	312	5.1†	16–9
Beech 1900	28.8†	310	4.7†	15–6
Beech King Air C90	27.3†	294	4.3†	14–3

*Aircraft with wing areas in excess of 279 m^2 (3000 ft^2).
†Data from *Jane's All the World's Aircraft.*

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A.4.1.3 Group III Aircraft Hangar. Group III aircraft hangars include any of the following:

(1) A freestanding unit for a single aircraft
(2) A row hangar with a common structural wall and roof system
(3) A hangar that houses multiple aircraft as well as having door openings for each aircraft
(4) An open-bay hangar capable of housing multiple aircraft

Figure A.4.1.3(a) through Figure A.4.1.3(c) are examples of Group III aircraft hangars.

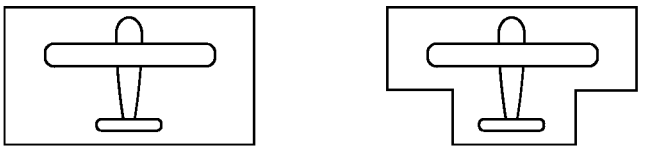


FIGURE A.4.1.3(a) Freestanding Units for Single Aircraft.

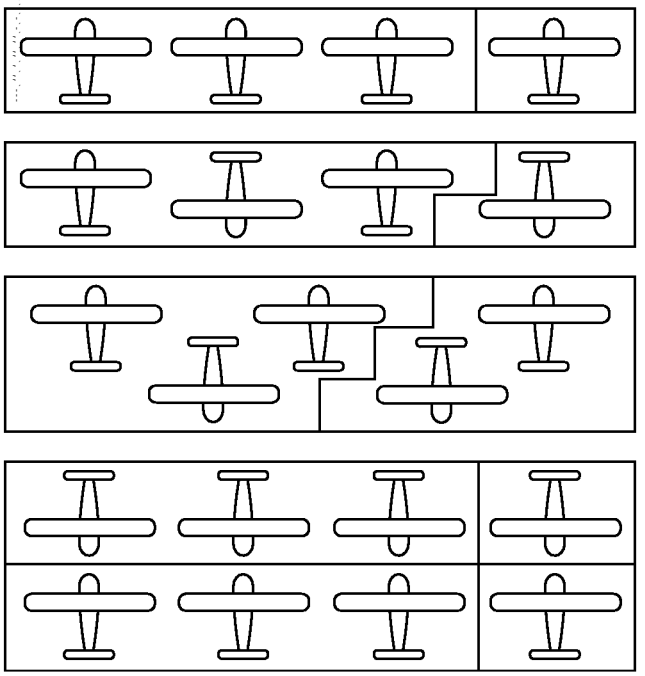


FIGURE A.4.1.3(b) Typical Configurations of Row Hangars.

A.5.1.1 Building construction types are defined in NFPA 220. See Annex B for more information.

A.5.1.2 Preference should be given to the use of noncombustible materials in Type V(111) and (000) hangars. Separate shops, offices, and storage areas should comply with the provisions of 5.2.1.

A.5.2.1 Fire wall construction should be in accordance with a listed construction assembly or the local building code. The construction should be resistant to or protected from mechanical damage and potential damage from discharge of the fixed fire protection system.

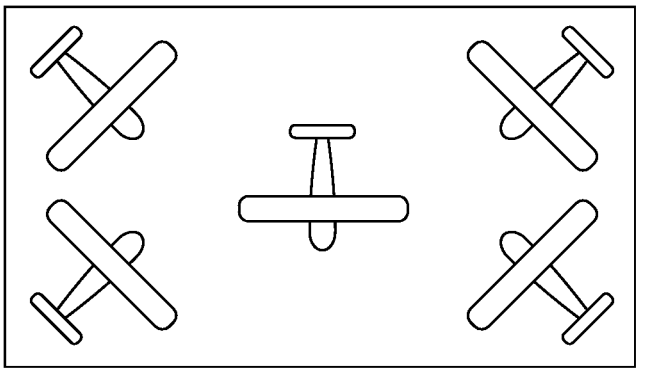


FIGURE A.4.1.3(c) Hangar Capable of Housing Multiple Aircraft.

Possible reasons to subdivide aircraft storage and service areas into separate fire areas include the following:

(1) Reducing required water supplies
(2) Reducing exposed values for insurance or other purposes
(3) Reducing exposure between occupants
(4) Modifying the hangar classification

A.5.2.3 Shops, office, and storage areas should be in separate, detached buildings. Workshops, offices, and storage areas having their own roof coverings and built within aircraft storage or servicing areas should have watertight roof deck coverings.

A.5.3.2.3 See also NFPA 80.

A.5.4.2 These special hazards include, but are not limited to, spray painting or doping areas, flammable liquid storage or mixing rooms, and so forth.

A.5.5.3 Construction types will dictate the need for sprinkler protection in these spaces.

A.5.6.3 Additional guidance pertaining to fixed water spray systems can be found in NFPA 15. This information can also be used in the design of foam–water systems and when extension of discharge devices from the overhead sprinkler system is used. The design of such protection should take into account factors such as the shape of the column, wetting of lower sprinklers, obstructions, and type of discharge device.

A.5.7.3 Preplanning should ensure availability of necessary auxiliary equipment such as tractors, cables, grapnels, and so forth, where manual operation is either impossible or too slow to allow prompt aircraft removal.

A.5.9.1 Landing gear pits, ducts, and tunnels located beneath the hangar floor should be avoided if possible because of the danger of accumulation of flammable liquids or vapors; where their use is essential, the protection measures specified in Section 5.9 should be followed. For floor drainage, see 5.11.2.

A.5.9.5 Sensors should be installed in accordance with the manufacturer's instructions and close attention paid to the recommended sensor spacing.

A.5.9.7 The venting arrangements will depend on the design of the pits, elevating platforms, and means of access. It might be necessary for part of the platform surface to be grated or perforated to provide adequate explosion venting area. The general principles in NFPA 68 should be followed.

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A.5.9.8 Consideration should be given to the selection of an extinguishing agent that could also be used as a means of inerting the pit in the event that flammable vapors are present concurrent with the loss of use of the ventilation system due to power failure, maintenance, or other causes.

A.5.11.2.2 Aircraft hangars also might require floor trench drainage systems to effectively dispose of water used for cleaning aircraft and hangar floor surfaces and water accumulation from possible flooding due to high groundwater tables, and to drain away water discharged from the fire protection equipment provided within the structure. Reference can be made to NFPA 415 for information on drainage systems and to Annex B of NFPA 15 for information on drainage equipment and arrangements.

A.5.11.2.4 In general, this means that the design has to be adequate to ensure that the liquid level at the center of the drain is below the top surface of the drain inlet grating for grated round, rectangular, and long trench-type inlets or below the floor surface in the case of a slit trench.

A.5.12.1 It is recommended that hangar heating, ventilating, and air-conditioning equipment fired with gas, liquid, or solid fuel be located in a fire-resistive or noncombustible detached building wherever possible.

A.5.12.4 Personnel should be fully instructed that in the event of a serious gasoline or similar flammable liquid spill on the hangar floor, the fans should be shut off.

A.5.13.2 See also 5.7.2 for power supply to doors accommodating aircraft.

A.5.14 All aircraft hangars should be surveyed to determine the need for approved lightning protection. Where installed, such systems should be listed. See NFPA 780.

A.5.15.1 As low a resistance as possible should be secured and maintained. Ten thousand ohms is a practical recommended maximum where determined by standard procedures. For further details on this subject, see NFPA 407 and NFPA 77.

A.5.15.3 Speedometer, preformed steel, or equivalent cable will minimize danger of employee hand injury.

A.5.17 *Depth of Draft Curtains.* Draft curtains should extend down from the roof or ceiling of aircraft storage and servicing areas not less than one-eighth of the height from the floor to the roof or ceiling. Under curved or sloping roofs extending to grade level or close to grade level, draft curtains need not be continued below 4.8 m (16 ft) from the floor.

Installation of Draft Curtains. Draft curtains should be installed, preferably at right angles to the hangar doors, forming roof pockets that are rectangular in shape. Hangars that are long and narrow, however, might best be subdivided by a "grid" system of draft curtains that are both at right angles and parallel to the doors. In arch-type hangars, draft curtains can be hung on exposed interior roof supports running parallel to the doors. The method of installation should be based on obtaining maximum operational efficiency from the sprinkler protection, taking into consideration mean wind conditions, floor drains, floor pitch, and details of occupancy usage.

Roof Sections as Draft Curtains. Structural features of a building that serve the purpose of draft curtains (roof monitors, sawtooth roofs, etc.) can be permitted in lieu of specially constructed draft curtains.

A.5.17.1 The reason for limiting a draft curtain area to 697 m^2 (7500 ft^2) is to improve detection and sprinkler response times, not to limit the fire suppression system size.

A.6.2.1.1 It is highly important and expedient that all applicable areas of responsibility, such as those that cover adequacy of water supplies, design, suitability of agent, application rates used, area covered, testing, flushing, approvals, and so forth, be clearly defined in the contract documents. This is important where there is shared responsibility for various portions of the fire protection systems.

A.6.2.2.2 The manual control valve for each individual sprinkler system should be located outside aircraft storage and servicing areas.

A.6.2.2.7 This provision is for the purpose of addressing obstructions that can be caused by hangar door positions. It is not intended to address interference due to wind.

A.6.2.3.1 Supplementary protection systems for hangars containing several aircraft, each having a wing area less than 279 m^2 (3000 ft^2), can be warranted. Such systems are recommended under the following conditions:

(1) Rapid control of a fuel fire exposing a single aircraft is considered essential.
(2) Strategically important military aircraft or multiple high valued aircraft are accommodated.
(3) Arrangement of aircraft within a hangar results in congestion and limited access to individual aircraft.

A.6.2.3.2 In general, the specified floor area would be the area under the wings and wing center sections of the aircraft. Configuration of aircraft and positioning of aircraft and ground equipment within an aircraft storage and servicing area can compromise the effectiveness of any supplementary protection systems. Original design and testing of such systems should anticipate obstructions on the floor (such as those created by working platforms) in providing protection over the specified floor areas. The discharge from overhead hangar protection systems might not protect the aircraft from a fire in the shielded areas beneath the wings and the wing center sections. The supplementary system is intended to provide protection in those shielded areas by controlling such fires quickly and preventing extensive damage to the aircraft. The area to be protected depends on the configuration and the number of aircraft and their positioning arrangements, as well as the location of permanent service structures within the aircraft maintenance and servicing area. Protection of the entire aircraft maintenance and servicing area could be required because of the variety of possible aircraft positioning arrangements.

The total area to be protected by a single system depends on the number and configuration of aircraft and their proximity to one another and the drainage arrangements. If more than one aircraft is located in any drainage system, the supplementary foam system preferably should be capable of covering the floor area beneath all such aircraft.

A.6.2.3.4.2 Experience has shown that the mechanism for manual operation of automatic oscillating monitor nozzles is a major factor in the failure rate of these devices. A large percentage of these failures have been due to operators failing to change the device from the manual to the automatic mode after testing and maintenance. The most reliable device is considered to be one that is designed for automatic operation only and that has no manual operating mode.

A.6.2.3.5.2 To achieve the design principles, the rate of foam rise should be at least 0.9 m/min (3 ft/min) beneath the aircraft wings and wing center section. With large shielded areas, a higher rate of foam rise could be required.

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The foam generators should be installed and positioned in such a way that the flow of foam on the floor is directed to areas beneath the aircraft wings and wing center section. If the fire spreads to the aircraft interior, it could seriously damage or destroy the aircraft unless an automatic fire extinguishing system is also provided inside the aircraft cabin. If generators are located on the exterior of the hangar, the possible hazards of freezing water on the generator screens should be considered. The discharge of high-expansion foam in the hangar space can handicap visibility for manual fire fighting.

A.6.2.3.5.5 See A.6.2.7.2.

A.6.2.4.1 A preaction standard sprinkler system should be used only if there is a possibility of freezing in an unheated hangar.

A.6.2.5.3 This design criterion can be achieved by means of multiple nozzles of the same or different capacities aimed to discharge toward the aircraft parking area. The fluidity of the foam will achieve coverage of the entire floor area.

A.6.2.5.4.2 It is recognized that the distribution of foam from this type of system will result in small areas that are not initially covered with foam. In addition, it is recognized that there are areas along the walls and corners that might not be covered with foam.

A.6.2.5.4.4 This design criterion can be achieved by means of multiple nozzles of the same or different capacities. The momentum and spreading characteristics of the foam will assist in achieving coverage of the entire floor area. It is not the intent that the initial discharge pattern of the nozzles cover the entire floor area. *(Also see A.6.2.3.4.2.)*

A.6.2.5.5.6 See A.6.2.7.2.

A.6.2.6 Experience has shown that different brands of foam might not be compatible and can have varying levels of fire-fighting effectiveness. Care should be utilized in the selection of foam concentrates. For further information, see NFPA 16.

A.6.2.6.2 Actual flow rates are often higher than calculated, which will often result in a reduction in foam supply duration.

A.6.2.6.3 Actual flow rates are often higher than calculated, which will often result in a reduction in foam supply duration.

A.6.2.7.2 Reliability of power supplies for drivers of water pumps, foam concentrate pumps, and foam generators will be a function of all the facilities between the pump driver and the power source. For a diesel engine–driven pump and an electric motor–driven pump, the independence of the power sources is clear. This, of course, assumes there is a battery-powered starter for the diesel engine. Independence of two diesel engines with separate fuel tanks is also fairly easily seen.

However, the degree of independence of the power sources for two electric-motor drivers is much more difficult to establish. A single controller, a single switchgear cabinet, or a single cable route might easily negate the desired reliability.

The considerations of power supply reliability are required in various sections of NFPA 20 and NFPA 16. These considerations should demonstrate that the power supply reliability is consistent with that achieved for the mechanical components. A number of methods are available. Such a method could be a simple inspection and statement of design philosophy or a sophisticated fault tree analysis.

A.6.2.8.2.2 In locating manual actuation stations inside, multiple stations should be considered to provide occupants with a selection of paths of exit from which they can actuate the system.

The location of exterior actuation stations should ensure accessibility once the occupant has exited the hangar through any of the emergency exits. Security fences, adjacent buildings, or other obstructions should be considered when locating exterior actuation stations.

A.6.2.8.3.1 Where separate detection systems are provided for actuation of the supplementary systems, they should be either a radiation (infrared or ultraviolet) or a heat-responsive (continuous strip type or thermistor type) system. When they are initially installed, if there is any doubt as to the stability of these actuating devices because of environmental factors, it is recommended that the devices be utilized to actuate only an alarm rather than trigger the extinguishing systems. As soon as operational experience indicates that the devices are stable, they should be arranged to automatically actuate the extinguishing equipment. Spacing of detection devices should be no greater than the maximum recommended by the manufacturer.

A.6.2.8.5.1 See A.6.2.8.3.1.

A.6.2.9 Subsection 6.2.9 provides a means for fire fighting by occupants of the hangar through the use of hand hose supplied from the hangar's fixed fire protection system or from an independent source. The hand hose system in aircraft storage and servicing areas is usually arranged for foam application with water spray or straight water streams used in other areas.

A.6.2.10.1 The presence of corrosion inhibitors, antifreeze agents, marine growth, oil, or other contaminants can result in the reduction of foam volume or stability. If the quality of the water used is questionable, the manufacturer of foam equipment should be consulted. In general, the performance of a foam–water extinguishing system depends on the agent composition, the proportioning concentration, and the application technique. Different brands or types of agents should not be mixed without the advice of the equipment manufacturer regarding their interchangeability and compatibility.

A.6.2.10.2.1 Actual flow rates are often higher than calculated. This will often result in a reduction in foam supply duration.

Aircraft storage and servicing areas with large doors on both ends can present special draft problems that affect the efficient operation of the sprinkler systems. In such cases, additional systems should be included in the calculation of water supply needed. Draft stops should effectively surround each individual sprinkler system. *(See Section 5.17.)*

A.6.2.10.7 The development of satisfactory water supplies is a matter requiring engineering judgment and careful analysis of local conditions. *(See NFPA 20 and NFPA 22.)* Acceptable types of water supplies can consist of one or more of the following:

(1) Connections to reliable waterworks systems, including automatic booster pumps where required
(2) Automatic fire pumps taking suction under a head from storage reservoirs or other suitable supply
(3) Gravity tanks

Combinations of these supplies can be used to advantage. It is desirable to have two independent water supplies. Where reliance is placed on automatic fire pumps, special consideration should be given to the use of multiple pumps

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rather than single pumps and the use of multiple sources of power in order to increase the reliability of pump drivers. Water supplies should be guarded against entry of foreign material that would clog sprinklers or piping. Waterworks connections, where used as an independent supply, should be capable of delivering water at the specified rate and pressure as determined by flow tests, with due consideration given to any conditions that could affect the design supply and pressure. Investigation should be made to determine the normal and emergency operation of the waterworks system, including domestic consumption and operation of the waterworks pumps at time of test, pressure-reducing valves, or other factors affecting adequacy of a public water supply. Automatic booster fire pumps should be used to provide effective pressure from waterworks connections.

A.6.2.10.8.4 Supplemental means for automatically starting the fire pumps should also be provided.

A.6.2.10.9 In connection with the flushing operation, preplanning should be made for means of disposing of the large quantities of water discharged.

A.6.2.11.9 System actuation is defined as actuation of the water control valve.

A.6.4 For further information, see *NFPA 72.*

A.7.2.1 A preaction standard sprinkler system should be used only if there is a possibility of freezing in an unheated hangar.

A.7.3 Experience has shown that different brands of foam might not be compatible and can have varying levels of fire-fighting effectiveness. Care should be utilized in the selection of foam concentrates. For further information, see NFPA 16.

A.7.3.6.3 System actuation is defined as actuation of the automatic water control valve.

A.7.4 Experience has shown that different brands of foam might not be compatible and can have varying levels of fire-fighting effectiveness. Care should be utilized in the selection of foam concentrates. For further information, see NFPA 16.

A.7.4.3 This design criterion can be achieved by means of multiple nozzles of the same or different capacities aimed to discharge toward the aircraft parking area. The fluidity of the foam will achieve coverage of the entire floor area.

A.7.4.5 Actual flow rates are often higher than calculated, which will often result in a reduction in foam supply duration.

A.7.5.8 System actuation is defined as actuation of the automatic water control valve.

A.7.6.7 This should be accomplished by providing manifolded drains.

A.7.8 See A.6.2.10.1.

A.8.1.1 Group III hangars for small aircraft either are prefabricated assemblies or are locally constructed of unprotected steel or aluminum, light wood framing, or cement or cinder blocks. The majority of the prefabricated types are unprotected steel structures with sheet steel or aluminum roof coverings and sidings. Other prefabricated hangars have wood or cement sidings and wood or plywood doors. Except in unusual circumstances, construction types other than Type II (000) and Type V (000) are unlikely because of cost factors. Earth floors are common. Floor drainage is not required for single-unit or row hangars, although utility drains are useful and should be provided. The airport operator should have a master key for the Group III hangars on the airport premises so as to provide emergency access in case of fire. *(See A.5.1.1.)*

A.8.4.4 Personnel should be fully instructed that in the event of a serious gasoline or similar flammable liquid spill on the hangar floor, the fans should be shut off.

A.8.5.2 See also 5.7.2 for power supply to doors accommodating aircraft.

A.8.7.1 As low a resistance as possible should be secured and maintained. A practical recommended maximum is 10,000 ohms (Ω) where determined by standard procedures. For further details on this subject, see NFPA 407 and NFPA 77.

A.8.7.3 Speedometer, preformed steel, or equivalent cable should minimize the danger of employee hand injury.

A.8.9.1 Fire loss history has shown that in aircraft hangars, regardless of size, if the fire event involves aircraft fuels, there is a significantly increased potential for loss of the hangar and contents if an automatic fire suppression system is not provided.

A.9.1 Membrane-covered rigid-steel-frame structures (Group IV hangars) are an evolving construction technology that is recognized by the model building codes and is being used for a variety of occupancies, including warehouses and hangars. The use of membrane-covered rigid-steel-frame structures for providing weather protection covering for aircraft has become a viable alternative to the traditional construction techniques that have been used for aircraft hangars. The fire protection scheme considered for these structures anticipates that, in the event of a fire, the structure will be self-venting.

A.9.12.3 Speedometer, preformed steel, or equivalent cable should minimize the danger of employee hand injury.

A.9.14.7.4.2 There is little concern for a large volume of water being associated with a high-expansion foam solution. In an aggregation of mechanically expanded foam, the ratio of air or other gases to foam–water solution ranges from 200:1 to approximately 1000:1.

A.9.14.10.2.1 Additional guidance pertaining to detection systems can be found in *NFPA 72.* The selection of fire detectors should take into account factors such as the following:

(1) The anticipated fuel
(2) The ability of the detectors to sense fire in the fire zone
(3) The speed at which the detector will sense the fire
(4) Potential sources of stimuli that could be falsely detected as a fire

Detection systems for low-level systems should be either a radiation (infrared or ultraviolet) or a heat-responsive (continuous strip–type or thermistor-type) system. Spacing of detection devices should be no greater than the maximum recommended by the manufacturer.

A.9.14.13.8.8 System actuation is defined as actuation of the automatic water control valve.

A.9.14.15 For further information, see *NFPA 72.*

A.10.3.3.1 The airflow velocity at every point should be within ±20 percent of the mean velocity across the cross-sectional area of the filters.

A.10.3.3.2 Where the provisions of 10.3.3.2 require shutting down the recirculation system, the exhaust system should remain in operation. In this event, recirculation air could be

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directed to the exterior of the building, thus stopping the recirculation process.

The recirculation airstream should not be considered part of the exhaust system for purposes of this standard.

A.10.4.5 Grounding is the process of bonding one or more conductive objects to the ground, so that all objects are at zero electrical potential. Refer to NFPA 77 for guidance on proper arrangements for grounding and bonding.

Annex B Building Construction Types

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

B.1 The material in Annex B is extracted from the 1999 edition of NFPA 220 and is included here as a convenience for users of this standard. Any requests for Formal Interpretations (FIs) or Tentative Interim Amendments (TIAs) on the following material should be directed to the Technical Committee on Building Construction.

B.2 Type I (443 or 332). Type I construction shall be that type in which the structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire resistance ratings not less than those specified in Table B.2. [**220:**3.1]

Requirements for fire resistance of exterior walls located in close proximity to property lines, other buildings, or exposures, the provision of spandrel wall sections, and the limitation or protection of wall openings are not related to type of construction. They could be specified in other standards and codes, where appropriate, and could be required in addition to the requirements of this standard for the type of construction. [**220:** A.3.1]

B.3 Type II (222, 111, or 000). Type II construction shall be that type not qualifying as Type I construction in which the structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire resistance ratings not less than those specified in Table B.2. [**220:**3.2]

B.4 Type III (211 or 200). Type III construction shall be that type in which exterior walls and structural members that are portions of exterior walls are of approved noncombustible or limited-combustible materials, and interior structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are entirely or partially of wood of smaller dimensions than required for Type IV construction or of approved noncombustible, limited-combustible, or other approved combustible materials. In addition, structural members shall have fire resistance ratings not less than those specified in Table B.2. [**220:**3.3]

B.5 Type IV (2HH). The dimensions used for sawn and glued laminated lumber in Section B.5 are nominal dimensions. [**220:** A.3.4]

B.5.1 Type IV construction shall be that type in which exterior and interior walls and structural members that are portions of such walls are of approved noncombustible or limited-combustible materials. Other interior structural members, including columns, beams, girders, trusses, arches, floors, and roofs, shall be of solid or laminated wood without concealed spaces and shall comply with the provisions of B.5.2 through B.5.6. In addition, structural members shall have fire resistance ratings not less than those specified in Table B.2.

Exception No. 1: Exterior walls greater than 30 ft (9.1 m) from the property line shall be permitted to be of heavy timber construction provided the 2-hour rating as required by Table B.2 is maintained and such walls contain no combustible concealed spaces.

Exception No. 2: Interior columns, arches, beams, girders, and trusses of approved materials other than wood shall be permitted, provided they are protected to provide a fire resistance rating of not less than 1 hour.

Exception No. 3: Certain concealed spaces shall be permitted by the exception to B.5.4. **[220:3.4.1]**

B.5.2 Wood columns supporting floor loads shall be not less than 8 in. (203 mm) in any dimension; wood columns supporting roof loads only shall be not less than 6 in. (152 mm) in the smallest dimension and not less than 8 in. (203 mm) in depth. [**220:**3.4.2]

B.5.3 Wood beams and girders supporting floor loads shall be not less than 6 in. (152 mm) in width and not less than 10 in. (254 mm) in depth; wood beams and girders and other roof framing supporting roof loads only shall be not less than 4 in. (102 mm) in width and not less than 6 in. (152 mm) in depth. [**220:**3.4.3]

B.5.4 Framed or glued laminated arches that spring from grade or the floor line and timber trusses that support floor loads shall be not less than 8 in. (203 mm) in width or depth. Framed or glued laminated arches for roof construction that spring from grade or the floor line and do not support floor loads shall have members not less than 6 in. (152 mm) in width and not less than 8 in. (203 mm) in depth for the lower half of the member height and not less than 6 in. (152 mm) in depth for the upper half of the member height. Framed or glued laminated arches for roof construction that spring from the top of walls or wall abutments and timber trusses that do not support floor loads shall have members not less than 4 in. (102 mm) in width and not less than 6 in. (152 mm) in depth.

Exception: Spaced members shall be permitted to be composed of two or more pieces not less than 3 in. (76 mm) in thickness where blocked solidly throughout their intervening spaces or where such spaces are tightly closed by a continuous wood cover plate not less than 2 in. (51 mm) in thickness, secured to the underside of the members.

Splice plates shall be not less than 3 in. (76 mm) in thickness. [**220:**3.4.4]

B.5.5 Floors shall be constructed of spline or tongue-and-groove plank not less than 3 in. (76 mm) in thickness that is covered with 1-in. (25-mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with ½-in. (12.7-mm) plywood; or they shall be constructed of laminated planks not less than 4 in. (102 mm) in width, set close together on edge, spiked at intervals of 18 in. (457 mm), and covered with 1-in. (25-mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with ½-in. (12.7-mm) plywood. [**220:**3.4.5]

B.5.6 Roof decks shall be constructed of spline or tongue-and-groove plank not less than 2 in. (51 mm) in thickness; or of laminated planks not less than 3 in. (76 mm) in width, set close together on edge, and laid as required for floors; or of 1⅛-in. (28.6-mm) thick interior plywood (exterior glue); or of approved noncombustible or limited-combustible materials of equivalent fire durability. [**220:**3.4.6]

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Table B.2 Fire Resistance Ratings (in hours) for Type I through Type V Construction

	Type I		Type II			Type III		Type IV	Type V	
	443	332	222	111	000	211	200	2HH	111	000
Exterior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting one floor only	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting a roof only	4	3	1	1	0[1]	2	2	2	1	0[1]
Interior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	2	1	0
Supporting one floor only	3	2	2	1	0	1	0	1	1	0
Supporting roofs only	3	2	1	1	0	1	0	1	1	0
Columns										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only	3	2	2	1	0	1	0	H[2]	1	0
Supporting roofs only	3	2	1	1	0	1	0	H[2]	1	0
Beams, Girders, Trusses, and Arches										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only	3	2	2	1	0	1	0	H[2]	1	0
Supporting roofs only	3	2	1	1	0	1	0	H[2]	1	0
Floor Construction	3	2	2	1	0	1	0	H[2]	1	0
Roof Construction	2	1½	1	1	0	1	0	H[2]	1	0
Exterior Nonbearing Walls[3]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

Those members that shall be permitted to be of approved combustible material.

[1]See NFPA 220, A-3-1 (table).

[2]"H" indicates heavy timber members; see NFPA 220 for requirements.

[3] Exterior nonbearing walls meeting the conditions of acceptance of NFPA 285, *Standard Method of Test for the Evaluation of Flammability Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus*, shall be permitted to be used.

[**220:** Table 3]

B.6 Type V (111 or 000). Type V construction shall be that type in which exterior walls, bearing walls, columns, beams, girders, trusses, arches, floors, and roofs are entirely or partially of wood or other approved combustible material smaller than material required for Type IV construction. In addition, structural members shall have fire resistance ratings not less than those specified in Table B.2. [**220:**3.5]

Annex C Informational References

C.1 Referenced Publications. The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

C.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2001 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2003 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2003 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2003 edition.

NFPA 68, *Guide for Venting of Deflagrations*, 2002 edition.

NFPA 72®, National Fire Alarm Code®, 2002 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2000 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 edition.

NFPA 220, *Standard on Types of Building Construction*, 1999 edition.

NFPA 285, *Standard Method of Test for the Evaluation of Flammability Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus*, 1998 edition.

NFPA 407, *Standard for Aircraft Fuel Servicing*, 2001 edition.

NFPA 410, *Standard on Aircraft Maintenance*, 2004 edition.

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NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways*, 2002 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 edition.

C.1.2 Other Publications.

C.1.2.1 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM G 155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*, 2001.

C.1.2.2 Jane's Information Group Publication. Jane's Information Group Ltd., Sentinel House, 163 Brighton Road, Coulsdon, Surrey C25 2YH, UK.

Jane's All the World's Aircraft, various editions.

C.2 Informational References. (Reserved)

C.3 References for Extracts. The following documents are listed here to provide reference information, including title and edition, for extracts given throughout the nonmandatory sections of this standard as indicated by a reference in brackets [ ] following a section or paragraph. These documents are not a part of the requirements of this document unless also listed in Chapter 2 for other reasons.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2003 edition.

NFPA 220, *Standard on Types of Building Construction*, 1999 edition.

NFPA 221, *Standard for Fire Walls and Fire Barrier Walls*, 2000 edition.

NFPA 5000®, Building Construction and Safety Code®, 2003 edition.

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