NFPA 409

Standard on Aircraft Hangars

2001 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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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 13–17, 2001, in Anaheim, CA. It was issued by the Standards Council on July 13, 2001, with an effective date of August 2, 2001, and supersedes all previous editions.

This edition of NFPA 409 was approved as an American National Standard on August 2, 2001.

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 (now the American Insurance Association) in 1930. Revisions were issued by the NBFU in 1931, 1943, 1945, and 1950. During the period 1943 through 1954, these recommendations were published as NBFU Pamphlet 85. In 1951, the National Fire Protection Association, Inc. organized a Committee on Aircraft Hangars to which the National Board of Fire Underwriters and other interested groups lent their support. The NFPA's first standard was adopted in 1954, and the NBFU adopted the same text, rescinding their earlier 1950 standard. Revisions were made in 1957 and 1958 by this NFPA Committee. In 1959, a reorganization of the NFPA aviation activities resulted in the assignment of this standard to the Sectional Committee on Aircraft Hangars and Airport Facilities. The 1960, 1962, 1965, 1966, 1967, 1969, 1970, 1971, 1972, 1973, and 1975 editions were prepared by this sectional committee. 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. This standard was 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.

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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.

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

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

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

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. The complete title and edition of the document the material is extracted from is found 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 appropriate technical committee.

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 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 alternate 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.

2.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers,* 1998 edition.

NFPA 11, *Standard for Low-Expansion Foam,* 1998 edition.

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

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1999 edition.

NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* 2000 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,* 1999 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 1999 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 1995 edition.

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

NFPA 54, *National Fuel Gas Code,* 1999 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2001 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 1997 edition.

NFPA 70, *National Electrical Code®,* 1999 edition.

NFPA 72®, *National Fire Alarm Code®,* 1999 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 1999 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 1999 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 1999 edition.

NFPA *101®*, *Life Safety Code®,* 2000 edition.

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

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings,* 1998 edition.

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways,* 1997 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films,* 1999 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 1997 edition.

2.1.2 Other Publications.

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

ASTM G 26, *Practice for Operating Light/Exposure Apparatus (Zenon-Arc Type) With and Without Water Exposure of Non-Metallic Materials,* 1993.

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.

3.2.2* Authority Having Jurisdiction. The organization, office, or individual responsible 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 stan-

dards 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, 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 system having a pipe connected to and including a source of foam concentrate and a water supply. Water and foam concentrate [protein, fluoroprotein, or aqueous film forming-foam (AFFF)] are delivered to open discharge devices for extinguishing agent discharge and for distribution over the area to be protected. The piping is connected to the water supply through an automatic valve that is actuated by the operation of a detection system installed in the same areas as the discharge devices. When this valve opens, water flows into the piping system, foam concentrate is injected into the water, and the resulting discharge of foam solution through the foam-water discharge devices generates and distributes foam. Upon exhaustion of the foam concentrate supply, water discharge will follow the foam and continue until shut off manually. [**16:**1.3]

3.3.8 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 5.3.3 or 8.3.1 of this standard, as appropriate.

3.3.9 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 Section 8.2 of this standard as appropriate.

3.3.10 Membrane. A thin, flexible, water impervious material capable of being supported by an air pressure of 38.1 mm (1.5 in.) of water column.

3.3.11 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 Sections 5.2 or 8.2 of this standard, as appropriate.

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

3.3.13 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.

3.3.14 Weathered-Membrane Material. Material that has been subjected to a minimum of 3000 hours in a weatherometer in accordance with ASTM G 26, *Practice for Operating Light/Exposure Apparatus (Zenon-Arc Type) With and Without Water Exposure of Non-Metallic Materials*, or approved equivalent. [**102:**2.2]

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

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

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

Table 4.1.2 Fire Areas for Group II Aircraft Hangars

Type of Construction	Single Fire Area Equal to or Greater Than But Not Larger Than	
	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

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

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, *Standard on Types of Building Construction*. 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, *Standard on Types of Building Construction*, 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* 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 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 and Table 5.3.3 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. Where the minimum clear space specified in Table 5.3.2 is not met, the buildings shall be considered a hangar building cluster.

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

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. These buildings shall be considered a hangar building cluster.

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 ¾ hour, 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.

5.3.3 The clear space distances specified in Table 5.3.3 shall be maintained on all sides of the hangar building clusters. Where mixed types of construction are involved, the less fire-resistant type of construction shall be used to determine required clear space differences.

Table 5.3.3 Clear Space Distances for Hangar Building Clusters

Type of Construction	Minimum Separation Required	
	m	ft
Type I (443) and (332)	23	75
Type II (222)	23	75
Type IV (2HH)	23	75
Type II (III) and Type III (211)	30	100
Type II (000)	30	100
Type III (200)	30	100
Type V (III) and (000)	38	125

5.3.3.1 Where the exposing wall and any openings therein of one hangar have a minimum fire resistance rating of at least 2 hours, the clear space distance shall be permitted to be reduced to not less than 15 m (50 ft) between hangar building clusters.

5.3.3.2* 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 ¾ hour, 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 shall be permitted to be reduced to not less than 15 m (50 ft) between hangar building groups. 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 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, *Standard Methods of Fire Tests of Roof Coverings*.

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 of noncombustible construction 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, *National Electrical Code®*.

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

5.9.6 As 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.

5.9.7* 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, *Standard on Explosion Prevention Systems*.

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 for NFPA *101®, Life Safety Code®*, special provisions for aircraft storage hangars, interior wall and ceiling finish criteria.

5.11 Drainage of Aprons and Hangar Floors.

5.11.1 The apron or approach at the entrance to the hangar shall slope away from the hangar with a minimum grade of one-half of one percent (1:200) for the first 15 m (50 ft). Ramps used for aircraft fueling adjacent to hangar structures shall comply with NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways*. 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 one-half of one 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 can serve each hangar trench drainage system, 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 sys-

tems 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, *Standard for the Installation of Air-Conditioning and Ventilating Systems*; NFPA 31, *Standard for the Installation of Oil-Burning Equipment*; NFPA 54, *National Fuel Gas Code*; NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems;* and NFPA 58, *Liquefied Petroleum Gas Code.*

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. 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. Openings in the walls of such rooms communicating with other portions of the hangar shall be restricted to those necessary for ducts or pipes. 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. Each such duct shall be protected with a listed automatic fire damper or door. 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 operations 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.

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, 5.12.5.3, and 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, *Standard for the Installation of Air-Conditioning and Ventilating Systems.*

5.12.7 Where blower and exhaust systems are installed for vapor removal, the systems shall be installed in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

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, *National Electrical Code.*

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, *Standard for the Installation of Lightning Protection Systems.*

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, Life Safety Code*.

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 696.8 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 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.

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, *Standard for the Installation of Sprinkler Systems*, and NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 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, *Standard for the Installation of Sprinkler Systems*, 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, *Standard for the Installation of Sprinkler Systems*, and NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 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 12.1 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. The demand calculation method shall be performed to determine the adequacy of the water supply. The supply calculation method shall be performed to determine the amount of foam concentrate required. 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. Variation below the required density shall not be permitted. Orifice plates, sprinklers of different orifice sizes, piping of less than 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.

Exception: Local application protection for columns.

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, *Standard for the Installation of Sprinkler Systems*, 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.

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, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.*

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

6.2.2.13 The discharge density from non air-aspirating discharge devices using AFFF-type foam solutions shall be a minimum of 6.5 L/min/m^2 (0.16 gal of foam solution per min per 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, *Standard for Low-Expansion Foam*, or NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems.*

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* Coverage of the specified floor area beneath the aircraft shall be by means of a horizontal foam discharge from nozzles located above floor level.

6.2.3.4.3* 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.

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

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

6.2.3.4.6 Electric power reliability for oscillating nozzles shall be in accordance with electric fire pump requirements of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

6.2.3.4.7 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, *Standard for Medium- and High-Expansion Foam Systems.*

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, *Standard for the Installation of Stationary Pumps for Fire Protection.*

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, *Standard for the Installation of Sprinkler Systems*, and the provisions of this chapter.

6.2.4.2 Sprinkler piping shall be hydraulically sized in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. 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 from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm of water per ft^2) over any 1394-m^2 (15,000-ft^2) area, including the hydraulically most demanding area as defined in NFPA 13, *Standard for the Installation of Sprinkler Systems*.

6.2.4.6 Sprinklers shall have a nominal orifice size of 12.7 mm (½ in.) or 13.5 mm (17⁄32 in.).

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, *Standard for the Installation of Sprinkler Systems*.

6.2.5 Low-Level Foam Protection Systems.

6.2.5.1 Hangars protected in accordance with 6.1.1(2) or (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, *Standard for Low-Expansion Foam*, or NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*.

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, *Standard for Low-Expansion Foam*.

6.2.5.4.1 Where AFFF concentrate is used, the minimum application rate shall be 4.1 L/min/m^2 (0.10 gpm of foam solution per ft^2). The minimum application rate shall be 6.5 L/min/m^2 (0.16 gpm of foam solution per 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, *Standard for the Installation of Stationary Pumps for Fire Protection*.

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, *Standard for Medium- and High-Expansion Foam Systems*.

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, *Standard for Medium- and High-Expansion Foam Systems*.

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, *Standard for the Installation of Stationary Pumps for Fire Protection*.

6.2.6* Foam Concentrate Supply.

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, *Standard for the Installation of Stationary Pumps for Fire Protection*, 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, *Standard for the Installation of Stationary Pumps for Fire Protection*, and NFPA 70, *National Electrical Code*. 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.

6.2.8 Detection/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®*, *National Fire Alarm Code®*.

6.2.8.1.3 Detection systems shall be provided with supervision as required by *NFPA 72*, *National Fire Alarm Code*.

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 3.3.13, 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, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*, and NFPA 11, *Standard for Low-Expansion Foam*.

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, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*, in all shop, office, and nonaircraft 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.

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 connect 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, *Standard for the Installation of Sprinkler Systems*.

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 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, *Standard for the Installation of Stationary Pumps for Fire Protection*, 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, *Standard for the Installation of Sprinkler Systems*.

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, *Standard for Water Spray Fixed Systems for Fire Protection*.

6.2.11 Acceptance Tests.

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

6.2.11.1.1 Hydrostatic pressure tests shall be conducted on each system as specified in NFPA 11, *Standard for Low Expansion Foam*; NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*; NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*; or NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, as applicable.

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

6.2.11.1.3 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.

6.2.11.1.4 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.

6.2.11.1.5 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.

6.2.11.1.6 Any proportioner not tested under the requirements of 6.2.11.1.4 or 6.2.11.1.5 shall be individually tested with foam concentrate to determine concentrate percentage.

6.2.11.1.7 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.

6.2.11.1.8 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.

6.2.12 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 in gallons per minute per square foot is available in all areas.

6.2.13.2 Where existing systems are designed with a discharge density higher than the minimum required discharge 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, *Standard for Portable Fire Extinguishers*.

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, *Standard for Portable Fire Extinguishers*.

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, *Standard for Portable Fire Extinguishers*.

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 gal of foam solution per min per 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, *Standard for the Installation of Sprinkler Systems.*

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, *Standard for the Installation of Sprinkler Systems*, and the provisions of this chapter.

7.2.2 Sprinkler piping shall be hydraulically sized in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

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 from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm of water per ft^2) over any 464.5-m^2 (5000-ft^2) area, including the hydraulically most demanding area as defined in NFPA 13, *Standard for the Installation of Sprinkler Systems.*

7.2.6 Sprinklers shall have a nominal orifice size of 12.7 mm (½ in.) or 13.5 mm (17⁄32 in.).

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, *Standard for the Installation of Sprinkler Systems.*

7.3* Foam Concentrate — General.

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, *Standard for the Installation of Stationary Pumps for Fire Protection*, 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).

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, *Standard for the Installation of Stationary Pumps for Fire Protection*, and NFPA 70, *National Electrical Code*. 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, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.* 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, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.*

7.3.6.2 Acceptance tests for foam extinguishing systems shall be performed in accordance with 6.2.11.1.1, 6.2.11.1.2, and 6.2.11.1.8.

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.

7.3.7 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, *Standard for Low-Expansion Foam.*

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

7.5 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, *Standard for Medium- and High-Expansion Foam Systems.*

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, *Standard for Medium- and High-Expansion Foam Systems.*

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, *Standard for the Installation of Stationary Pumps for Fire Protection.*

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.

7.6 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, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.*

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 3.6 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 2.5 cm (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, National Fire Alarm Code.*

7.7.3 Detection systems shall be provided with supervision as required by *NFPA 72, National Fire Alarm Code.*

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, *Standard for the Installation of Sprinkler Systems*.

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, *Standard on Types of Building Construction*.

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, *Standard Methods of Fire Tests of Roof Coverings*.

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*, *Life Safety Code*.

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.

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 ¾ hour.

8.3 Hangar Building Clusters.

8.3.1 In hangar building clusters, Group III hangars within that 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.

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.

Table 8.3.1 Maximum Fire Areas for Hangar Building Clusters

Types of Construction	Hangar Building Clusters	
	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

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, 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, *Standard for the Installation of Air-Conditioning and Ventilating Systems*; NFPA 31, *Standard for the Installation of Oil-Burning Equipment*; and NFPA 54, *National Fuel Gas Code*, 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. 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. Openings in the walls of such rooms communicating with other portions of the hangar shall be restricted to those necessary for ducts or pipes. 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. Each such duct shall be protected with a listed automatic fire damper or door. 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 installed 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 means of the operations 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, 8.4.5.3, and 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 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, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 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, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

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, *National Electrical Code.*

8.6 Lightning Protection. Where provided, lightning protection shall be installed in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems.*

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*, *Life Safety Code*.

8.8.1.1 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.

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, *Standard for Portable Fire Extinguishers*. 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, *Standard for Portable Fire Extinguishers*.

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, *Standard for Portable Fire Extinguishers*.

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 the above, 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 this section's use of the categories of noncombustible and limited-combustible materials 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*, *Life Safety Code*.

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, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*.

9.1.5.4 Fabric materials shall be listed or approved for their intended use.

9.1.5.5 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.

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

9.1.5.7 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 them through which heated air can be moved to guard against ice accumulation. In lieu of the above, 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, *Standard on Types of Building Construction*, in all membrane-covered, rigid, steel frame–structure-type 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 separa-

tion 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, *National Electrical Code*.

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 lower flammable limit. 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, *Standard on Explosion Prevention Systems*.

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*, *Life Safety Code*.

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.

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, *National Electrical Code*.

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, Life Safety Code*.

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), 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), 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, *Standard for the Installation of Sprinkler Systems*, and the provisions of this chapter.
   (b) Sprinkler piping shall be hydraulically sized in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.
   (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 from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm of water per ft^2) over any 464.5-m^2 (5000-ft^2) area, including the hydraulically most demanding area as defined in NFPA 13, *Standard for the Installation of Sprinkler Systems*.
   (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, *Standard for the Installation of Sprinkler Systems*.

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), 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, *Standard for the Installation of Sprinkler Systems*.

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, *Standard for the Installation of Sprinkler Systems*.

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 within the protected area within 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, *Standard for Low-Expansion Foam*, or NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*.

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.

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 location 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 (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, *Standard for Low-Expansion Foam*, or NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems.*

9.14.7.3 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 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, *Standard for Low-Expansion Foam.*

9.14.7.4.1 Where AFFF concentrate is used, the minimum application rate shall be 4.1 L/min/m^2 (0.10 gpm of foam solution per ft^2). The minimum application rate shall be 6.5 L/min/m^2 (0.16 gpm of foam solution per 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, *Standard for the Installation of Stationary Pumps for Fire Protection.*

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, *Standard for Medium- and High-Expansion Foam Systems.*

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, *Standard for Medium- and High-Expansion Foam Systems.*

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 6 and 7 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

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, either protein foam, fluoroprotein, 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 service 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, *Standard for the Installation of Stationary Pumps for Fire Protection*, and NFPA 70, *National Electrical Code.* 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.

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/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, National Fire Alarm Code*.

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, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*, and NFPA 11, *Standard for Low-Expansion Foam*, or NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*.

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, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*, in aircraft storage and servicing areas having a hangar fire area greater than 1115 m^2 (12,000 ft^2) 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), 9.14.2(2), 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, *Standard for the Installation of Sprinkler Systems*.

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 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, *Standard for the Installation of Stationary Pumps for Fire Protection*, and in accordance with the provisions of 9.14.13.2 through 9.14.13.6.

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 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, *Standard for the Installation of Sprinkler Systems*.

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, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

9.14.13.8 Acceptance Tests.

9.14.13.8.1 The following tests 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, *Standard for Low-Expansion Foam*; NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*; NFPA 13, *Standard for the Installation of Sprinkler Systems*; or NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*, 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.

9.14.13.9 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, *Standard for Portable Fire Extinguishers*.

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, *Standard for Portable Fire Extinguishers*.

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, *Standard for Portable Fire Extinguishers*.

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

Chapter 10 Periodic Inspection and Testing

10.1 Fire Protection Systems.

10.1.1 Inspection and testing of fire protection systems in aircraft hangars shall be performed in accordance with Table 10.1.1.

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

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

Table 10.1.1 Inspection and Testing of Hangar Fire Protection Systems

System Components	Type and Frequency of Inspections and Tests					
	Weekly	Monthly	Semi-Annually	Annually	Quarterly	5 Yrs
Sprinkler Heads				V		
Piping				V		D
Pipe Hangers				V		
Sprinkler Alarm Valve		V			0, 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		
Conc. Storage Tanks		V				
Conc. Pump	F, 4			O		D
Conc. Control Valve (Auto)		V		O		D
Conc. Shutoff Valve		V		F		
Foam Prop. Device		V				D
H_2O Powered Mon. Noz.		V		D		
Elec. Powered Man. Noz.		V		F		D
H_2O Powered HEF Gen.		V		O		D
Elec. Powered HEF Gen.		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 & Remote)		F				
Tamper Switch					F	
Flow Indication Switch				O		
Supervisory Alarms			F			
Manual Actuation Stations			F			
Hangar Floor Drain Sys. & Separators		V				D
Fire Doors		V		F		
Gas Detectors		V	F			
Ventilation System in Pits, Tunnels, & Ducts			F			
Grounding Equipment						F

V = Visual
F = Functional (No flow)
O = Operational (W/Flow — No Discharge)
D = Operational with actual discharge
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

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. The phrase "authority having jurisdiction" 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.

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-3xx*			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
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

(continues)

Table A.3.3.2 *Continued*

Aircraft	Gross Wing Area		Overall Height	
	m^2	ft^2	m	ft–in.
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
Canadiar 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
Canadiar 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
Embaraer 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
Embaraer 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
Beach 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 3000 ft^2(279 m^2)

***Jane's All the Worlds Aircraft*, Various Editions, Jane's Information Group Limited, Sentinel House, 163 Brighton Road, Coulsdon, Surrey, CR5 2YH, UK

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.

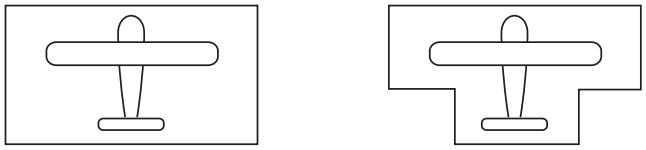

FIGURE A.4.1.3(a) Freestanding unit for single aircraft.

A.5.1.1 Building construction types are defined in NFPA 220, *Standard on Types of Building Construction*. 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.

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