NFPA®

409

Standard on Aircraft Hangars

2022

NFPA®

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2022 Edition

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

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NFPA® 409

Standard on

Aircraft Hangars

2022 Edition

This edition of NFPA 409, *Standard on Aircraft Hangars*, was prepared by the Technical Committee on Airport Facilities. It was issued by the Standards Council on October 2, 2021, with an effective date of October 22, 2021, and supersedes all previous editions.

This edition of NFPA 409 was approved as an American National Standard on October 22, 2021.

Origin and Development of NFPA 409

The original fire protection recommendations for the construction and protection of airplane hangars were published by the National Board of Fire Underwriters (NBFU), now the American Insurance Association, in 1930. Revisions were issued by the NBFU in 1931, 1943, 1945, and 1950. The 1943, 1945, and 1950 editions were published as NBFU Pamphlet 85.

In 1951, the National Fire Protection Association organized a Committee on Aircraft Hangars, to which the NBFU and other interested groups lent their support. NFPA's first standard on aircraft hangars was adopted in 1954 and NBFU adopted the same text, rescinding its 1950 standard. Revisions were made in 1957 and 1958 by the NFPA committee.

In 1959, a reorganization of NFPA's aviation standards resulted in the assignment of NFPA 409 to the Sectional Committee on Aircraft Hangars and Airport Facilities, which prepared the 1960, 1962, 1965, 1966, 1967, 1969, 1970, 1971, 1972, 1973, and 1975 editions. In 1978, the sectional committee was reorganized as the Technical Committee on Airport Facilities and completed a revision of NFPA 409. The document underwent extensive editorial revision and partial technical revision in 1984 and was again revised in 1990 and 1995.

For the 2001 edition of NFPA 409, the fire protection requirements for Group I hangars were extensively revised, and new criteria were added for membrane-covered rigid-steel-frame-structure hangars.

The 2004 edition of this standard was a partial revision.

The 2011 edition of NFPA 409 was another partial revision. Criteria were added to clarify where sprinklers are required for smaller hangars, such as those used by general aviation entities. In addition, unenforceable terms were removed to comply with the *Manual of Style for NFPA Technical Committee Documents*.

For the 2016 edition of NFPA 409, the committee re-examined many of the long-standing requirements with respect to current technologies, modern design practices, and known fire loss history. That fresh look resulted in the relaxation of the requirements for divided water reservoirs, redundant fire pumps, and reserve supplies of foam concentrate, among others. In addition, the requirements for the zoning of low-level foam systems were changed to permit Group I and Group II hangars, and Chapter 8 was simplified for Group III hangars.

The 2022 edition includes both new provisions and updates to existing sections of NFPA 409. In Chapter 1, new sections on application and retroactivity have been added to allow for their use within the standard. Several new definitions have been added in Chapter 3 to provide further context for the technical changes made during this revision cycle. A new Chapter 4, Fire Protection Approaches, has been introduced, and it allows for an evaluation of the fire risks and hazards for an aircraft hangar as found on a specific site. Complementing Chapter 4 is the new Chapter 5, Performance-Based Design Approach. This chapter permits the use of a performance-based design for aircraft hangars based on specified criteria and a final approval performed by the authority having jurisdiction. In Chapter 6, a new section on ignitable liquid drainage floor assemblies has

been added to permit the use of this protection method within specified hangars. Changes to Chapter 11 outline revised and new inspection, testing, and maintenance requirements that have applicability across several NFPA documents. Finally, changes to other existing requirements, as well as updates pertaining to general organization and reference publications, have been provided.

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Ronald J. Megasko, Marsh Risk Consulting, PA [I]
(Alt. to Lee T. Rindfuss)
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(Alt. to Craig W. Cook)
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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.

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

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Standard on

Aircraft Hangars

2022 Edition

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

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

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

Chapter 1 Administration

1.1 Scope.

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

1.1.2 This standard applies only to buildings or structures used for aircraft storage, maintenance, or related activities. Other uses within an aircraft hangar shall be protected in accordance with other applicable NFPA standards.

N **1.1.3*** This standard applies to aircraft hangars containing aircraft that use liquid hydrocarbon fuels.

1.2* Purpose. 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.

N **1.3 Application.** The application of this standard shall be permitted to be based on the risk considerations outlined in Chapter 4.

N **1.3.1** A documented risk assessment shall be permitted to be the basis for the implementation of this standard.

N **1.4 Retroactivity.** The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued. [**13:**1.4]

N **1.4.1** Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive. [**13:**1.4.1]

N **1.4.2** In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate. [**13:**1.4.2]

N **1.4.3** The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided. [**13:**1.4.3]

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 New Technology.

1.6.1 Nothing in this standard shall be intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered.

1.6.2 Materials or devices not specifically designated by this standard shall be utilized in complete accord with all conditions, requirements, and limitations of their listings.

1.7 Units.

1.7.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

1.7.1.1 The units are listed in Table 1.7.1.1 with conversion factors.

Table 1.7.1.1 Metric Units of Measurement

Name of Unit	Unit Symbol	Conversion Factor
Liter	L	1 gal = 3.785 L
Millimeter	mm	1 in. = 25.4 mm
Meter	m	1 ft = 0.305 m
Kilogram	kg	1 lb (mass) = 0.454 kg
Degree Celsius	°C	(5/9) (°F – 32) = °C
Bar	bar	1 psi = 0.0689 bar

1.7.1.2 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement.

1.7.1.3 A given equivalent value can be considered approximate.

1.7.2 The conversion procedure for the SI units is to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

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.

Δ **2.2 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing,* 2021 edition.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2022 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, (withdrawn)* 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2022 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2020 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2021 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2020 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 2021 edition.

NFPA 54, *National Fuel Gas Code,* 2021 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2020 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2019 edition.

NFPA 70®, National Electrical Code®, 2020 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2022 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives,* 2022 edition.

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

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 2021 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids,* 2020 edition.

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

NFPA 220, *Standard on Types of Building Construction,* 2021 edition.

NFPA 410, *Standard on Aircraft Maintenance,* 2020 edition.

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways,* 2022 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films,* 2019 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 2020 edition.

2.3 Other Publications.

2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials,* 2020.

ASTM G155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials,* 2013.

2.3.2 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2022 edition.

NFPA 70®, National Electrical Code®, 2020 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 2021 edition.

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

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls,* 2021 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

3.2.4 Shall. Indicates a mandatory requirement.

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

3.2.6 Standard. An NFPA standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases "standards development process" or "standards development activities," the term "standards" includes all NFPA standards, including codes, standards, recommended practices, and guides.

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 of which any part of an aircraft is housed. This does not apply to aircraft weather shelters that have two or more open sides or that have no means to enclose an aircraft.

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* Defueled Aircraft. An aircraft that has never been fueled or whose fuel system has had flammable or combustible liquid removed to meet one of the following criteria: (1) Individual tanks/cells contain less than 1 percent of their volumetric capacity; (2) Aircraft is drained to remove fuel to the greatest extent possible utilizing sump drains and other accessible non-maintenance means.

3.3.6 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.

3.3.7 Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating. [**221,** 2021]

3.3.8 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**, 2021]

Δ **3.3.9 Foam-Water Deluge System.** A foam-water sprinkler system employing open discharge devices, which are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system, which is installed in the same areas as the discharge devices. [**11**, 2021]

3.3.10 Gross Wing Area. See 3.3.20, Wing Area.

3.3.11 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 7.3 or 10.2 of this standard, as appropriate.

N **3.3.12* Liquid Drainage Floor Assembly.** A drainage system that allows liquids to flow into a listed floor system where liquid is removed from the hangar.

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

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

N **3.3.15* Professional Engineer.** A person registered or licensed to practice engineering in a jurisdiction, subject to all laws and limitations imposed by the jurisdiction. (SAF-FUN) [***101*,** 2021]

N **3.3.16 Qualified.** A competent and capable person who has met the requirements and training for a given field acceptable to the AHJ. [**96,** 2021]

3.3.17 Single Hangar Building. A building with one area for the storage and servicing of aircraft and any attached, adjoining, or contiguous structure, such as a lean-to, shop area, or parts storage area not separated as specified in Section 7.3 or 10.2 of this standard, as appropriate.

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

3.3.19 Weathered-Membrane Material. Membrane material that has been subjected to a minimum of 3000 hours in a weatherometer in accordance with ASTM G155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*, or approved equivalent.

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

N Chapter 4 Fire Protection Approaches

N **4.1 Fire Protection Approach.** The fire protection approach for aircraft hangars shall be permitted to be determined based on an evaluation of the fire risks, hazards associated with the site, services provided, the business continuity planning, and disaster restoration capabilities of the aircraft hangar specific to the site.

N 4.1.1 The fire protection approach shall be permitted to be established with consideration given to the following factors:

(1) The threat to facility occupants, the general public, emergency responders, and exposed property from a fire occurring at the facility or adjacent to or within the hangar
(2) The importance of the continuity of the operations being performed in the hangar, the value of the facility and its contents, and the potential for environmental impact
(3) Methods and equipment employed as part of a risk management or business continuity strategy that allow the hangar or aircraft to remain operable during and after an event or to be replaced or restored
(4) The potential for a given protection strategy to result in a service or business interruption or inhibit the ability of the aircraft hangar to operate in a timely manner post-event

N 4.1.2 The fire protection approach shall be developed using one of the following strategies within the aircraft storage and service areas:

(1) A prescriptive-based approach in accordance with this standard
(2) A fire risk-based approach in accordance with 4.1.3 and Section 4.2

N 4.1.3 A fire risk-based approach shall be permitted to be used to determine the construction, fire suppression, fire detection, and utility requirements of the aircraft storage and service areas that are necessary to achieve the purpose of this standard where specifically permitted by this standard. *(See Section 1.2.)*

N 4.2 Fire Risk Assessment.

N 4.2.1* The fire risk-based approach permitted by 4.1.2, also known as the risk assessment, shall be documented and approved by the authority having jurisdiction (AHJ).

N 4.2.2 The fire risk assessment shall include an evaluation of the risk management considerations outlined in 4.2.3 and involve all aircraft hangar stakeholders.

N 4.2.2.1 Fire risk assessment documents shall be prepared by a licensed professional engineer with experience in all aspects of fire protection and life safety system design for aircraft hangars and they shall be acceptable to the AHJ.

N 4.2.3* At a minimum, the following risk management elements shall be documented and considered to determine the level of acceptable fire risk as part of the fire risk assessment:

(1) Type and quantity of fuel in the aircraft or if the aircraft is unfueled
(2) Type of operations and activities performed within the aircraft storage and service area
(3) Risk of flammable or combustible liquid spills and equipment or the process for containment and control
(4) Life safety aspects of an emergency event within the aircraft storage and service area
(5) Fire threat to the hangar occupants and exposed property or operations in aircraft storage and service areas
(6) Continuity of service, operation, and the effects of business interruption, including the business or operational impact of a loss of aircraft (specifically military and unique aircraft)
(7) Quantity, size, and value of the aircraft within the hangar
(8) Size and value of the hangar
(9) Economic loss from loss of function or business interruption
(10) Economic loss from value of equipment other than the aircraft or the hangar
(11) Regulatory and reputation impact
(12) Potential environmental impact
(13) Construction and compartmentation of the aircraft storage and service area
(14) Fire suppression and detection features provided for the aircraft storage and service area
(15) Response time by emergency forces to an alarm
(16) Local firefighting capabilities and resources
(17) Evaluation and acknowledgment of hull and hangar insurance representatives
(18) Redundant infrastructure, including off-site aircraft hangars to support operations
(19) Redundant equipment, including replacement aircraft and other equipment within the aircraft hangar or the aircraft
(20) Life safety of emergency responders, the general public, and occupants of aircraft storage and service areas and adjacent spaces
(21) Life cycle costs

N 4.2.4 The fire risk assessment shall address the entire aircraft hangar, including all the adjacent support areas and exposures.

N 4.2.5 An approved, performance-based approach, in accordance with Chapter 5, shall be permitted to be applied selectively to specifically identified areas, hazards, or equipment or the specific fire protection requirements for the aircraft storage and service area as an alternative to the risk-based approach outlined in this chapter.

N 4.2.6 Independent Review. The AHJ shall be permitted to require an approved, independent third party to review the proposed fire risk assessment.

N 4.2.7 Risk Assessment Documentation and Follow-Up. The key components and requirements of the risk assessment shall be documented and located within the facility.

N 4.2.8 It shall be the responsibility of the facility owner/operator to ensure that the operations and hazards within the facility align with the risk assessment performed.

N Chapter 5 Performance-Based Design Approach

N 5.1 Performance-Based Design Approach. The requirements of Chapter 5 shall be used to recognize performance-based practices.

N 5.2 Goals and Objectives. The performance-based design shall meet the following goals and objectives:

(1) Allow an alternative means to be utilized for elements of an aircraft hangar as permitted in this standard
(2) The risk assessment, design criteria, design brief, system performance, and testing criteria are developed in accordance with this section
(3) Meet the scope and purpose of the standard as detailed in Section 1.1 and Section 1.2
(4) The performance-based design provides equivalent level of protection to the prescriptive requirements of this standard

N **5.3* Qualifications.** The performance-based design documents shall be prepared by a licensed professional engineer with experience in fire protection and life safety system design, risk assessments, and acceptable to the AHJ.

N **5.4* Independent Review.** The AHJ shall be permitted to require an approved, independent third party to review the proposed design brief based and the Performance-Based Design Report and the Design Brief.

N **5.5 Final Determination.** The authority having jurisdiction shall make the final determination as to whether the performance objectives have been met.

N **5.6 Maintenance of Performance-Based Design Approach.** The design features required for an aircraft hangar to continue to meet the performance goals and objectives of this standard shall be maintained for the life of the building. A re-evaluation of the Performance-Based Design Report shall be performed every 3 years by a licensed professional engineer to ensure compliance.

N **5.7 Performance Criteria.**

N **5.7.1 General.** All designs shall meet the goals and objectives specified in Section 5.2 and the performance criterion of 5.7.2, and all the aircraft hangar stakeholders shall concur with the design and risk management considerations.

N **5.7.2 Performance Criterion.** In addition to life safety considerations, the performance criterion shall include the protection of the aircraft storage and service area from damage by fire or its associated effects, including smoke, corrosion, heat, and water.

N **5.7.3 Aircraft Hangar Stakeholders.** Aircraft hangar stakeholders shall include, but not be limited to, the following:

(1) Registered professional engineers experienced in fire protection and life safety system design and risk assessments
(2) The owner or owner's representative
(3) Hull and hangar insurance representatives
(4) Representatives of the authority having jurisdiction
(5) Representatives of emergency response entities
(6) Building design professionals (architectural, structural, civil, mechanical, plumbing, and electrical design professionals)

N **5.7.4*** The design of the aircraft hangar shall include the preparation of a Design Brief that is prepared utilizing recognized performance-based design practices.

N **5.7.4.1*** Any deviation from a prescriptive requirement in this standard shall be detailed in the Design Brief and the Performance-Based Design Report.

N **5.7.4.2** Design specifications and briefs used for performance-based design shall be clearly documented and proven to be realistic and sustainable.

N **5.7.4.3*** Specific inspection, testing, and maintenance requirements that are necessary to maintain the reliable performance of the fire safety features of an aircraft storage and servicing area shall be stated in the Performance-Based Design Report.

N **5.7.4.4** The applicable items of Chapter 11 of this standard shall apply and include inspections, testing, and maintenance items and frequencies unless specified otherwise in the Performance-Based Design Report.

Chapter 6 Aircraft Hangar Groups

6.1 Aircraft Hangar Classification. For the purposes of this standard, aircraft hangars shall be classified as specified in 6.1.1 through 6.1.4.

6.1.1 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)

6.1.2 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 6.1.2

6.1.3 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 6.1.3

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

Table 6.1.2 Fire Areas for Group II Aircraft Hangars

	Single Fire Area (Inclusive)	
Type of Construction	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 6.1.3 Maximum Fire Areas for Group III Aircraft Hangars

	Maximum Single Fire Area	
Type of Construction	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 7 Construction of Group I and Group II Aircraft Hangars

N **7.1 Defueled Aircraft.** Defueled aircraft hangars shall comply with Chapter 7, except as modified by Chapter 14.

N **7.1.1** The construction requirements in 7.2.1 shall be permitted to be modified where a risk assessment, as outlined in Chapter 4, identifies that an alternative means of construction is acceptable.

7.2 Types of Construction.

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

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

7.3 Internal Separations.

7.3.1* Where aircraft storage and servicing areas are subdivided into separate fire areas, the separation shall be by a fire barrier wall having not less than a 2-hour fire resistance rating. Any openings in such fire barrier walls communicating directly between two aircraft storage and servicing areas shall be provided with a listed 2-hour fire door or 2-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 2 hours.

7.3.2 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 7.3.1. The other wall shall comply with 7.3.3.

7.3.3* 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.

7.3.4 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.

7.4 Clear Space Distance Requirements Around Hangars.

7.4.1 Precautions shall be taken to ensure ready access to hangars from all sides. Separation shall be provided to reduce fire exposure between buildings. The clear spaces specified in Table 7.4.1 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.

7.4.2 For single hangar buildings, the clear space distances specified in Table 7.4.1 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 the clear space required.

Table 7.4.1 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

7.4.2.1 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.

7.4.2.2 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.

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

7.5 Floors.

7.5.1 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.

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

7.5.3 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.

7.6 Roofs.

7.6.1* 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.

7.6.2 Where insulated metal deck assemblies are used, they shall meet or exceed FM Class 1 or UL Fire Classified ratings.

7.6.3* 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.

7.7 Primary Structural Steel Columns Supporting the Roof.

7.7.1 In aircraft storage and servicing areas, protection of columns shall be required in accordance with Section 7.7.

7.7.2 All 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.

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

7.7.3* 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.

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

7.7.3.2 The use of nozzles or open-head sprinklers with any nominal K-factor for column protection shall be permitted.

7.7.3.3 A listed strainer shall be provided on the supply side of sprinklers with nominal K-factors of less than K-2.8 (40). [**13:**9.4.4.2(3)]

7.7.3.4* Vertical structural steel members shall be protected by nozzles and piping of such size and arrangement as to discharge a net rate of not less than 10.2 $(L/min)/m^2$ $(0.25\ gpm/ft^2)$ over the wetted area. [**15:**7.4.3.4]

7.7.3.5 Discharge devices for the protection of columns within the remote area of the overhead sprinkler systems shall be included in the calculations for the overhead system.

7.7.4 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.

7.8 Doors.

Δ **7.8.1** Hangar doors that accommodate aircraft shall be constructed of noncombustible materials; limited-combustible materials; materials having a Class A flame spread rating when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*; or materials passing the NFPA 701 test method.

7.8.2 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.

7.8.3* Vertical traveling doors shall be counterbalanced, and horizontal slide or accordion-type doors shall be arranged so that the doors can be opened through manual or auxiliary operation.

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

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

7.10 Landing Gear Pits, Ducts, and Tunnels.

7.10.1* 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.

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

7.10.3 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 daily operations and be designed to discharge externally to the hangar.

7.10.4 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.

7.10.5* 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 7.10.4 automatically upon detection of a specified flammable vapor concentration that is below the lower flammable limit (LFL). The detection system shall have sensors located throughout all ducts and tunnels.

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

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

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

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

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

7.10.8* An approved fire protection system shall be installed to protect each pit unless the hangar fire protection required by either Chapter 8 or Chapter 9 is designed to protect each pit.

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

7.12 Drainage of Aprons and Hangar Floors.

7.12.1 Apron Drainage.

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

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

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

7.12.2 Hangar Floor Trench Drainage.

7.12.2.1 In aircraft storage and servicing areas of hangars, floor trench drainage or liquid drainage floor assemblies in accordance with 7.12.2.2 through 7.12.2.12 shall be provided.

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

7.12.2.3 Trench drainage systems and liquid drainage floor assemblies 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 traps or be provided with ventilation to prevent vapor mixtures from forming within the underground trench drainage system.

7.12.2.4 Trench drainage systems and liquid drainage floor assemblies in aircraft storage or servicing areas shall be designed and constructed so that they have a capacity large enough 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.

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

7.12.2.6 Each trench drainage system or liquid drainage floor assembly 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.

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

7.12.2.8 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.

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

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

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

7.12.2.12 Grates and drain covers shall support the point loading of the heaviest type aircraft or equipment to be housed in the hangar. Grates and covers shall be removable to facilitate cleaning and flushing.

N **7.12.2.13** The aircraft storage and service area floor drainage requirements in 7.12.2.1 through 7.12.2.12 shall be permitted to be modified where a risk assessment, as outlined in Chapter 4, identifies that an alternative means of floor drainage is acceptable.

7.13 Heating and Ventilating.

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

7.13.2 In aircraft storage and servicing areas, no heating, ventilating, and air-conditioning equipment employing an open flame or glowing element shall be installed, other than as provided for in 7.13.5.

7.13.3 In aircraft storage and servicing areas, hangar heating plants that are fired with gas, liquid, or solid fuels not covered under 7.13.5 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.

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

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

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

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

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

7.13.4* In aircraft storage and servicing areas, 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.

7.13.4.1 Where automatic fire protection systems are installed in aircraft storage and servicing areas, fans for furnace heating systems shall be arranged to shut down automatically by means

of the operation of the interior automatic fire protection system.

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

7.13.4.1.2 Shutoff switches shall be accessible and clearly placarded.

7.13.5 Suspended or Elevated Heaters.

7.13.5.1 In aircraft storage and servicing areas, listed electric, gas, or oil heaters shall be permitted to be used if installed as specified in 7.13.5.2 through 7.13.5.4.

7.13.5.2 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 are capable of being 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.

7.13.5.3 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.

7.13.5.4 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.

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

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

7.14 Lighting and Electrical Systems.

7.14.1 Artificial lighting shall be restricted to electric lighting.

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

7.14.3 In aircraft storage and servicing areas, main distribution panels, metering equipment, and other 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.

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

7.16 Grounding Facilities for Static Electricity.

7.16.1* Aircraft storage and servicing areas, 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 7.16.2 and 7.16.3.

7.16.2 Floor-grounding receptacles shall be provided and 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 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.

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

7.17 Exit and Access Requirements.

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

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

7.18* Draft Curtains.

7.18.1 Draft curtains shall be required in Group I hangars.

7.18.2 Draft curtains shall be required in Group II hangars only where foam-water deluge sprinkler systems are provided per the requirements of 8.1.1(1).

7.18.3* Draft curtain areas shall be around each roof/ceiling fire suppression system and subdivided such that a single draft curtain area shall not exceed 697 m^2 (7500 ft^2). The maximum projected floor area under an individual sprinkler system shall be in accordance with Chapters 8 and 9.

7.18.4 Where provided, 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.

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

7.18.6 Where provided, 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 7.18.5.

N **7.18.7** The draft curtain requirements in 7.18.1 through 7.18.3 shall be permitted to be modified where a risk assessment, as outlined in Chapter 4, identifies that an alternative means of draft curtains is acceptable.

Chapter 8 Protection of Group I Aircraft Hangars

8.1 General.

8.1.1 The protection of aircraft storage and servicing areas for Group I aircraft hangars shall be in accordance with any one of the following:

(1) A foam-water deluge system, as specified in 8.2.2. In addition, supplementary protection systems as specified in 8.2.3 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 8.2.4 and an automatic low-level low-expansion foam system in accordance with 8.2.5.
(3) A combination of automatic sprinkler protection in accordance with 8.2.4 and an automatic low-level high-expansion foam system in accordance with 8.2.5.
(4) A combination of automatic sprinkler protection in accordance with 8.2.4 and an ignitable liquid drainage floor assembly in accordance with 8.2.13.

N **8.1.1.1** The protection requirements in 8.1.1 shall be permitted to be modified where a risk assessment, as outlined in Chapter 4, identifies that an alternative means of protection is acceptable.

8.1.2 Group I aircraft hangar storage and service areas housing defueled aircraft shall be provided with protection in accordance with 8.1.1 or with automatic sprinkler protection as specified in Chapter 14.

8.1.3 Where the provisions of Chapter 14 are used, no provisions of Chapter 8 shall be required.

8.1.4 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 protection in accordance with 8.1.1 or with automatic fire protection systems.

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

Δ **8.1.6** Additional protection, as specified in Sections 8.3 and 8.4, shall be provided in all Group I aircraft hangars in addition to other protection systems required by this chapter.

8.1.7 Each foam protection system shall be designed, installed, and maintained in accordance with NFPA 11, except as modified by this chapter.

8.1.8 Foam solution piping shall be permitted to be any ferrous material meeting the requirements of NFPA 13.

8.2 Fire Protection Systems.

8.2.1 Plans and Specifications.

8.2.1.1* 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.

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

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

N **8.2.1.3** Where a fire risk assessment or a performance-based design approach is utilized as permitted in Chapters 4 and 5 of this standard, the Performance-Based Design Report and summary of the fire risk assessment shall be included in the aircraft hangar plans and specifications.

8.2.2 Deluge Foam-Water Sprinkler System Design and Performance.

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

8.2.2.2* 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).

8.2.2.3 In aircraft storage and servicing areas, the protection area as projected on the floor shall be limited to 12 m^2 (130 ft^2). The maximum distance between sprinklers either on branch lines or between branch lines shall be 3.7 m (12 ft). In buildings with storage bays 7.6 m (25 ft) wide, a distance of 3.8 m (12 ft 6 in.) shall be permitted.

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

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

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

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

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

8.2.2.6 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 8.2.2.12 or 8.2.2.13.

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

8.2.2.6.2 Variation below the required density shall not be permitted.

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

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

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

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

8.2.2.10 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.

8.2.2.11 Strainers shall be installed in accordance with NFPA 16.

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

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

8.2.3 Supplementary Protection Systems.

8.2.3.1* Hangars protected in accordance with 8.1.1(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.

8.2.3.2* 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.

8.2.3.3 Supplementary Low-Expansion Foam Systems.

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

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

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

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

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

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

8.2.3.4 Supplementary High-Expansion Foam Systems.

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

8.2.3.4.2* 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.

8.2.3.4.3* Discharge rates shall include the rate of foam breakdown by sprinklers that is specified in NFPA 11.

8.2.3.4.4 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.

8.2.3.4.5* Foam generators shall be listed.

8.2.3.4.6 Electric power reliability for electric blower–type foam generators shall be in accordance with electric fire pump requirements of NFPA 20.

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

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

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

8.2.4.3 Sprinkler spacing shall be as specified in 8.2.2.3.

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

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

8.2.4.5.1 The design area of the closed-head water sprinkler system shall not be required to be increased for ceiling slope.

8.2.4.5.2 The design area of the closed-head water sprinkler system shall not be required to be increased for preaction systems.

8.2.4.6 Sprinklers shall be nominal K-80 (K-5.6) or K-115 (K-8.0) sprinklers.

8.2.4.7 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.

8.2.5 Low-Level Foam Protection Systems.

8.2.5.1 Hangars protected in accordance with 8.1.1(2) or 8.1.1(3) shall be protected with a listed low-level foam protection system.

8.2.5.2* The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and service area.

8.2.5.2.1 The performance 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, or within the design area of operation noted in 8.2.5.2.3, within 3 minutes of system actuation when all foam discharge devices of the system are activated.

8.2.5.2.2 Low-level foam systems shall be permitted to be divided into zones that are associated with sprinkler system or fire detection zones.

N **8.2.5.2.3** Low-level, low-expansion foam systems shall be designed for simultaneous operation of all systems within a 30 m (100 ft.) radius horizontally from any point where a fire could start.

8.2.5.3 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.

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

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

8.2.5.3.3 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.

8.2.5.3.4* 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.

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

8.2.5.4 Low-Level High-Expansion Foam Systems.

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

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

8.2.5.4.3* The discharge rate of the system shall be based on the rate of foam breakdown by sprinklers that is specified in NFPA 11 and the application rate multiplied by the entire aircraft storage and servicing floor area.

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

8.2.5.4.5 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.

Δ **8.2.5.4.6** Foam generators shall be listed.

N **8.2.5.4.7*** Electric power reliability for electric blower–type foam generators shall be in accordance with electric fire pump requirements of NFPA 20.

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

8.2.6.1* The quantities of low-expansion foam concentrate, either protein foam, fluoroprotein, or AFFF, shall be large enough for a 10-minute foam discharge based on the supply calculation in 8.2.2.4.

8.2.6.2* The quantity of high-expansion foam concentrate shall be large enough for a 12-minute discharge at the water flow rate based on the supply calculation method required in 8.2.2.4.

8.2.6.3 A reserve supply of foam concentrate shall be provided in accordance with 4.3.2.5.2 of NFPA 11.

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

8.2.7 Foam Concentrate Pumps.

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

8.2.7.2* 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 are 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).

8.2.7.3 Where a connected foam concentrate reserve is provided, piping shall be arranged so that maximum foam concentrate demand shall be supplied by any foam concentrate pump from either primary or reserve foam concentrate tanks.

8.2.7.4 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.

8.2.7.5 The pressure regulating valve shall not be used as the pressure relief valve.

8.2.7.6 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.

8.2.7.7 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).

8.2.7.8 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.

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

8.2.7.10 Controllers for foam concentrate pumps shall be as follows:

(1) For electric-drive foam concentrate pumps, a listed full-service electric foam pump controller shall be used.
(2) For diesel engine–driven foam concentrate pumps, a listed fire pump controller shall be used.

8.2.8 Detection and Actuation System Design.

8.2.8.1 General.

8.2.8.1.1 Actuation systems shall be provided with complete circuit supervision and shall be arranged in accordance with Section 8.4.

8.2.8.1.2 These detection systems shall be installed in accordance with *NFPA 72*.

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

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8.2.8.2 Deluge Foam-Water Sprinkler Systems.

8.2.8.2.1* Detectors for actuating the deluge foam-water sprinkler systems shall be listed flame detectors or heat detectors of the rate-of-rise, fixed-temperature, or rate-compensation type.

8.2.8.2.2* 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.

8.2.8.3 Supplementary Protection Systems.

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

8.2.8.3.2 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.

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

8.2.8.5 Low-Level Foam Protection Systems.

8.2.8.5.1* Actuation of any closed-head sprinkler system or fire detection system shall simultaneously operate the low-level foam protection system.

8.2.8.5.2* Where the foam system is automatically activated per 8.2.8.5.1, all foam discharge devices that are wholly or partly associated with the area of coverage of the sprinkler system or fire detection zone shall be discharged.

8.2.8.5.3 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 positions to facilitate early system actuation in the event of a fire.

8.2.8.5.4 Actuation of any manual actuation station shall simultaneously operate all low-level foam discharge devices over the entire aircraft storage and service area.

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8.2.9* Water Supply.

8.2.9.1* At least one automatic water supply capable of supplying all required or installed fire suppression systems that are designed to operate simultaneously, including, but not limited to, sprinkler systems, foam-generating systems, and hand hose lines, shall be provided.

8.2.9.2 Deluge Foam-Water Sprinkler Systems.

8.2.9.2.1* The water supply shall be capable of furnishing water for the largest number of systems that are designed 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.

8.2.9.2.2 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 8.2.9.3.

8.2.9.3 Supplementary Protection Systems. Where supplementary protection is installed in accordance with 8.2.3, the total water supply duration shall be for a minimum of 45 minutes.

8.2.9.4 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.

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8.2.9.5 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 inclu-

ded in the water supply hydraulic calculations. Calculations for hose stream shall be in accordance with NFPA 13.

8.2.9.6 Fire Pumps.

8.2.9.6.1 Fire pumps shall be installed in accordance with NFPA 20 and in accordance with the provisions of 8.2.9.6.2 through 8.2.9.6.5.

8.2.9.6.2 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.

8.2.9.6.3* 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.

8.2.9.6.4 Where pressure is used as the starting sequence for fire pumps, a small auxiliary pressure maintenance pump or other suitable means to maintain normal system pressures shall be provided.

8.2.9.6.5 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.

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

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

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

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

8.2.10.3 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 are designed 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.

8.2.10.4 The smallest single foam-water deluge system shall be discharged using foam concentrate or a listed or approved alternative test method (*see NFPA 11*). This test shall be run for a length of time to stabilize discharge before test samples are taken to determine the proportioning rate.

8.2.10.5 The maximum number of systems expected to operate shall be simultaneously discharged with foam or a listed or approved alternative test method (*see NFPA 11*). This test shall be run for a length of time to stabilize discharge before test samples are taken to determine the proportioning rate.

8.2.10.6 Any proportioner not tested under the requirements of 8.2.10.4 or 8.2.10.5 shall be individually tested with foam concentrate or a listed or approved alternative test method (*see NFPA 11*) to determine the proportioning rate.

8.2.10.7 Supplementary and low-level protection systems shall be subjected to foam flow tests with foam, or a listed or approved alternative test method (*see NFPA 11*), flowing simultaneously from the maximum number of sprinkler systems expected to operate, 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, proportioning rate, and other operating characteristics are satisfactory.

8.2.10.7.1 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 or a listed or approved alternative test method (*see NFPA 11*) in the supplementary protection system.

8.2.10.8 Supplementary and low-level protection systems shall be examined visually to determine that they have been installed correctly. 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 identified and operating instructions prominently posted.

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

8.2.11 Final Approval. The installing company shall furnish a written statement that the work has been completed in accordance with 8.2.1 and tested in accordance with the provisions of 8.2.10.

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

8.2.12.1 If water supplies are greater than necessary, the uniform discharge requirement of 8.2.2.6 shall be permitted to be waived if the required minimum discharge rate is available in all areas.

8.2.12.2 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.

8.2.12.3 Converted systems shall be tested in accordance with 8.2.10.

***N* 8.2.13 Ignitable Liquid Drainage Floor Assemblies.**

N* 8.2.13.1 Ignitable liquid drainage floor assemblies shall be listed and installed in accordance with the manufacturer's instructions.

***N* 8.2.13.2** Design of the drainage system shall remove fuel through the drainage system from the aircraft storage and service area.

N* 8.2.13.3 The floor dimensions shall be large enough to cover all the fuel-containing parts of the aircraft where a fuel spill could occur and address lateral discharge potential per the manufacturer's written instructions.

N **8.2.13.4** The floor assembly shall have a drainage rate that is greater than 110 percent of the total anticipated fuel discharge rate, plus an allowance for the required sprinkler flow.

N **8.2.13.4.1** A minimum fuel flow rate of 757 L/min (200 gpm) shall be used for the floor design calculations for an aircraft up to 24 m (78 ft) in length with a fuselage width of 4 m (13 ft) or less. For larger aircraft, the minimum fuel flow rate used for floor design calculations shall be 1514 L/min (400 gpm).

N **8.2.13.5** Discharge piping must be of sufficient size to allow for an unrestricted flow to a point of containment or disposal outside of the hangar structure, as approved.

8.3 Wheeled and Portable Extinguishers.

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

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

8.3.3 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.

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

Chapter 9 Protection of Group II Aircraft Hangars

9.1 General.

9.1.1* The protection of aircraft storage and servicing areas of Group II aircraft hangars shall be in accordance with any one of the following:

(1) The provisions of Chapter 8, unless foam-water deluge systems utilizing air-aspirating discharge devices are installed for the protection of Group II aircraft hangars, in which case the discharge rate specified in 8.2.2.12 of this standard is permitted to be reduced to a minimum of 6.5 L/min/m^2 (0.16 gpm/ft^2) of floor area
(2) A combination of automatic sprinkler protection in accordance with Section 9.2 and an automatic, low-level, low-expansion foam system in accordance with Sections 9.3 and 9.4
(3) A combination of automatic sprinkler protection in accordance with Section 9.2 and an automatic, high-expansion foam system in accordance with Sections 9.3 and 9.5
(4) A closed-head foam-water sprinkler system in accordance with Section 9.6
(5) A combination of automatic sprinkler protection in accordance with Section 9.2 and an ignitible liquid drainage floor assembly in accordance with 8.2.13

N **9.1.1.1** The protection requirements in 9.1.1 shall be permitted to be modified where a risk assessment, as outlined in Chapter 4, identifies that an alternative means of protection is acceptable.

9.1.2 Group II aircraft hangar storage and service areas housing defueled aircraft shall be provided with automatic sprinkler protection as specified in Chapter 14.

9.1.3 Where the provisions of Chapter 14 are used, no provisions of Chapter 9 shall be required.

9.1.4 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.

N **9.1.5** For the protection of aircraft storage and servicing areas of Group II aircraft hangars where hazardous operations, including but not limited to fuel transfer, welding, torch cutting, torch soldering, doping, hot work (e.g., welding, cutting, brazing, grinding), spray painting, oxygen service, composite repairs, fuel system or fuel tank maintenance, aircraft cabling, wiring changes, or initial electrical system testing, are not performed, a closed-head automatic sprinkler system in accordance with Section 9.2 shall be permitted.

Δ **9.1.6** In addition to the provision for sprinkler and foam extinguishing systems as required by this chapter, protection as required by Sections 8.3 and 8.4 also shall be provided.

9.1.7 Each foam protection system shall be designed, installed, and maintained in accordance with NFPA 11, except as modified by this chapter.

9.1.8 Foam solution piping shall be permitted to be any ferrous material meeting the requirements of NFPA 13.

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

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

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

9.2.3 Sprinkler spacing shall be as specified in 8.2.2.3.

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

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

9.2.5.1 The design area of the closed-head water sprinkler system shall not be required to be increased for ceiling slope.

9.2.5.2 The design area of the closed-head water sprinkler system shall not be required to be increased for preaction systems.

9.2.6 Sprinklers shall be nominal K-80 (K-5.6) or K-115 (K-8.0) sprinklers.

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

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

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

Δ **9.3.2** A reserve supply of foam concentrate shall be provided in accordance with 4.3.2.5.2 of NFPA 11.

9.3.3 Foam Concentrate Pumps.

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

9.3.3.2 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 are 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).

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

9.3.3.4 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.

9.3.3.5 The pressure-regulating valve shall not be used 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.

9.3.3.6 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).

9.3.3.7 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.

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

9.3.3.9 Controllers for foam concentrate pumps shall be as follows:

(1) For electric-drive foam concentrate pumps, a listed full-service fire pump controller shall be used.
(2) For diesel engine–drive foam concentrate pumps, a listed fire pump controller shall be used.

9.3.4 The control valves, foam–liquid concentrate storage, injection system, and foam concentrate pump shall be located outside aircraft storage and servicing areas.

9.3.5 Plans and specifications for closed-head foam-water sprinkler systems shall provide the information required by 8.2.1 of this standard and NFPA 16. Plans and specifications for other foam extinguishing systems shall provide the information required by 8.2.1.

9.3.6 Acceptance Tests.

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

9.3.6.2 Acceptance tests for foam extinguishing systems shall be performed in accordance with 8.2.10.1, 8.2.10.2, 8.2.10.6, and 8.2.10.8.

9.3.6.2.1 The maximum number of discharge devices expected to operate shall be subjected to flow tests using foam concentrate, or a listed or approved alternative test method (see *NFPA 11*), 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, and proportioning rate are satisfactory.

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

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

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

9.3.7 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 9.3.6.

9.4* Low-Expansion Foam System.

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

9.4.2* Low-expansion foam systems shall be designed for simultaneous operation of all systems within a 30 m (100 ft.) radius horizontally from any point where a fire could start.

9.4.3 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.

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

Δ **9.4.5** The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and service area.

N **9.4.6** The performance 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 or within the area of operation noted in 9.4.2 within 3 minutes of system actuation.

9.5 High-Expansion Foam System.

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

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

Δ **9.5.3*** The discharge rate of the system shall be based on the rate of foam breakdown by sprinklers that is specified in NFPA 11 and the application rate multiplied by the entire aircraft storage and servicing floor area.

9.5.4 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.

Δ **9.5.5** Foam generators shall be listed.

N **9.5.6** Electric power reliability for electric blower–type foam generators shall be in accordance with electric fire pump requirements of NFPA 20.

9.5.7 The quantity of foam concentrate shall be calculated to operate the system at the required discharge rate as determined in 9.5.3 for a period of at least 12 minutes.

9.5.8 The low-level foam system shall be designed to achieve distribution of foam over the entire aircraft storage and service area. The performance 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.

9.6 Closed-Head Foam-Water Sprinkler System.

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

9.6.1.1 AFFF shall be used.

9.6.1.2 Wet pipe foam-water systems shall not be required to be preprimed with foam-water solution.

9.6.2 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.

9.6.2.1 The design area of the closed-head foam-water sprinkler system shall not be required to be increased for ceiling slope.

9.6.2.2 The design area of the closed-head foam-water sprinkler system shall not be required to be increased for preaction systems.

9.6.3 Sprinkler spacing shall not exceed 9.3 m^2 (100 ft^2) as projected on the floor. The maximum distance between sprinklers either on branch lines or between branch lines shall be 3.7 m (12 ft). In buildings with storage bays that are 7.6 m (25 ft) wide, 3.8 m (12 ft 6 in.) shall be permitted.

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

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

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

9.6.6 Foam concentrate supply shall be in accordance with 8.2.6.

9.6.7* Branch lines shall be provided with provisions for flushing in accordance with NFPA 25 and NFPA 11.

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

9.7 Detection and Actuation Systems.

9.7.1* Detectors for actuating preaction sprinkler systems shall be listed flame detectors or heat detectors of the rate-of-rise, fixed-temperature, or rate-compensation type.

Δ **9.7.2*** Detectors for actuating high- or low-expansion foam systems shall be listed flame detectors or heat detectors of the rate-of-rise, fixed-temperature, rate-compensation type, or water flow of a wet pipe sprinkler system.

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

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

9.7.5 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.

9.7.6 Listed detection systems shall be acceptable in lieu of heat detection if approved by the authority having jurisdiction and installed in accordance with *NFPA 72*.

9.8* Water Supply.

9.8.1 The total water supply shall be calculated to satisfy the combination of systems and hose stations as described in 9.1.1(2), 9.1.1(3), and 9.1.4 for durations as specified in 9.8.2 through 9.8.7.

9.8.2 The water supply for closed-head water sprinkler systems in aircraft storage and servicing areas shall have a minimum duration of 30 minutes at the rate specified in 9.2.5.

9.8.3 The water supply for low-expansion foam systems shall be capable of furnishing water at the rate specified in 9.4.1 for a period of time equal to at least twice the period of time used to calculate the quantity of foam–liquid concentrate in 9.4.4.

9.8.4 The water supply for high-expansion foam systems shall be capable of furnishing water at the rate specified in 9.5.2 for a minimum period of 24 minutes.

9.8.5 The water supply for closed-head foam-water sprinkler systems shall have a minimum duration of 30 minutes at the rate specified in 9.6.2.

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

9.8.7 Where provided, fire pumps shall be designed and installed in accordance with 8.2.9.6.

Chapter 10 Group III Aircraft Hangars

10.1 Construction.

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

10.1.2 Group III aircraft storage and servicing areas shall be limited to one story.

10.1.2.1 Where a Group III aircraft storage and servicing area exceeds one story, the hangar shall be designated as a Group II hangar.

10.1.3 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.

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

10.1.5 A minimum of 15 cm (6 in.) high curbing shall be provided between each aircraft storage and servicing area to prevent the flow of liquid from one space to adjacent spaces.

10.1.6 Group III hangars protected with the fire protection specified in Chapter 9 shall be provided with floor drainage in accordance with Section 7.12.

10.1.7* Roof coverings shall be listed as Class C or better.

10.1.8 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*.

10.2 Separation and Internal Subdivisions.

10.2.1 For single hangar buildings, the clear-space distances specified in Table 10.2.1 shall be maintained on all sides of the single hangar. Where mixed types of construction are involved, the least fire-resistant type of construction shall be used to determine the clear space required.

10.2.1.1 Where single hangar buildings adjoin, each one has fire barrier walls with a minimum rating of at least 2 hours, and each one is located so that fire areas shall not exceed the maximum areas specified in Table 6.1.3, no minimum separation distance shall be required.

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

Table 10.2.1 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

10.3 Heating and Ventilating.

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

10.3.2 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 10.3.5.

10.3.3 Hangar heating plants that are fired with gas, liquid, or solid fuels not covered under 10.3.5, 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.

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

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

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

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

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

10.3.4* 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.

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

10.3.5 Suspended or Elevated Heaters.

10.3.5.1 Listed electric, gas, or oil heaters shall be permitted to be used if installed as specified in 10.3.5.2 through 10.3.5.4.

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

10.3.5.3 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.

10.3.5.4 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.

10.3.6 Where a mechanical ventilating system is employed in hangars or shops, the ventilating system shall be installed in accordance with NFPA 90A and in accordance with the applicable provisions of Section 10.3.

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

10.4 Lighting and Electrical Systems.

10.4.1 Artificial lighting shall be restricted to electric lighting.

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

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

10.6 Grounding Facilities for Static Electricity.

10.6.1* 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.

10.6.2 Floor-grounding receptacles shall be provided and 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.

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

10.7 Exit and Access Requirements.

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

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

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

10.8 Fire Protection for Group III Hangars.

10.8.1 Group III Fire Protection.

10.8.1.1* Fixed fire protection systems shall be installed where required by and in accordance with locally adopted building codes.

10.8.1.2* In addition to the requirement of 10.8.1.1, 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 9 and also shall meet the requirements specified in 7.5.2.

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

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

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

Chapter 11 Group IV Aircraft Hangars

11.1* Construction.

11.1.1 When membrane-covered rigid-steel-frame structures are used for the construction of aircraft hangars, they shall be constructed in accordance with Chapter 11.

11.1.2 The hangar shall be limited to one story.

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

11.1.4 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 public service electrical supply. In lieu of such heating elements, any other approved methods that protect against ice accumulation shall be permitted.

11.1.5 Membrane Materials.

11.1.5.1 Testing of membrane materials for compliance with the use of the categories of noncombustible and limited-combustible materials in accordance with 11.1.5 shall be performed on weathered membrane material.

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

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

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

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

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

11.2 Internal Separations.

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

11.2.2 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.

11.2.3 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.

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

11.4 Aprons and Floors.

11.4.1 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.

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

11.5 Doors.

11.5.1 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.

11.5.2 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.

11.5.3 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.

11.5.4* 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.

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

11.7 Landing Gear Pits, Ducts, and Tunnels.

11.7.1 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.

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

11.7.3 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 regular operations and be designed to discharge externally to the hangar.

11.7.4 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.

11.7.5 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 11.7.4 automatically upon detection of a specified flammable vapor concentration that is below the lower flammable limit (LFL). The detection system shall have sensors located throughout all ducts and tunnels.

11.7.6 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 separator fuel traps shall be provided. Where automatic pumping facilities are necessary, they shall be approved 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.

11.7.7 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.

11.7.8 An approved fire protection system shall be installed to protect each pit unless the hangar fire protection required by Section 11.14 is designed to protect each pit.

11.8 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*.

11.9 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 7.12.

11.10 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 7.13.

11.11 Lighting and Electrical Systems.

11.11.1 Artificial lighting shall be restricted to electric lighting.

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

11.11.3 In hangars with aircraft storage and servicing areas greater than 1115 m^2 (12,000 ft^2), housing other than defueled aircraft, main distribution panels, metering equipment, and other 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.

11.12 Grounding Facilities for Static Electricity.

11.12.1 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.

11.12.2 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 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.

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

11.13 Exit and Access Requirements.

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

11.13.1.1 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.

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

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

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

(1) A low-expansion foam system as specified in 11.14.7.4
(2) A high-expansion foam system as specified in 11.14.7.5
(3) An ignitible liquid drainage floor assembly in accordance with 8.2.13

N **11.14.1.1** The fire protection requirements in 11.14.7.4 and 11.14.7.5 shall be permitted to be modified where a risk assessment, as outlined in Chapter 4, identifies that an alternative means of fire protection is acceptable.

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

(1) A low-expansion foam system as specified in 11.14.7.4
(2) A high-expansion foam system as specified in 11.14.7.5
(3) Automatic sprinkler protection that complies with the following and Section 9.8 (for the water supply):
    (a) Closed-head water sprinkler system for aircraft storage and servicing areas. Sprinkler systems shall be either wet pipe or preaction and shall be designed and installed in accordance with the applicable sections of NFPA 13 and the provisions of this chapter.
    (b) Sprinkler piping shall be hydraulically sized in accordance with NFPA 13.
    (c) Sprinkler spacing shall be as specified in 8.2.2.3.
    (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 the required floor coverage.
    (e) The design density of water from sprinkler systems shall be a minimum of 6.9 L/min/m^2 (0.17 gpm/ft^2) over any 464.5 m^2 (5000 ft^2) area, including the hydraulically most demanding area as defined in NFPA 13.
    (f) Sprinklers shall have a nominal orifice size of 12.7 mm (½ in.) or 13.5 mm (17/32 in.).
    (g) Quick-response sprinklers having a temperature rating of 79.4°C (175°F) shall be used. Quick-response sprinklers having a temperature rating of 93.3°C (200°F) or 28°C (50°F) above the highest ambient temperature shall be permitted in areas subject to high ambient temperatures.
    (h) Sprinkler systems shall be flushed and tested in accordance with NFPA 13.

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

11.14.4 In Group IV hangars that require protection in accordance with 11.14.1, 11.14.2, or 11.14.3, 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.

11.14.5 Protection Systems.

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

11.14.5.2 Each foam system shall be designed, installed, and maintained in accordance with NFPA 11.

11.14.5.3 Foam solution piping shall be permitted to be any ferrous material meeting the requirements of NFPA 13.

11.14.6 Plans and Specifications.

11.14.6.1 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.

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

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

11.14.7 Low-Level Foam Protection Systems.

11.14.7.1 Hangars protected in accordance with 8.1.1(2) or 8.1.1(3) shall be protected with a listed low-level foam protection system.

11.14.7.2 Each low-level foam protection system shall be designed, installed, and maintained in accordance with NFPA 11, except as modified by this chapter.

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

11.14.7.4 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.

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

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

11.14.7.4.3 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.

11.14.7.4.4 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.

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

11.14.7.5 Low-Level High-Expansion Foam Systems.

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

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

Δ **11.14.7.5.3** The discharge rate of the system shall be based on the application rate multiplied by the entire aircraft storage and servicing floor area.

N **11.14.7.5.4*** When sprinklers are provided, the discharge rate shall include the rate of foam breakdown by sprinklers that is specified in NFPA 11.

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

11.14.7.5.6 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.

Δ **11.14.7.5.7** Foam generators shall be listed.

N **11.14.7.5.8** Electric power reliability for electric blower–type foam generators shall be in accordance with electric fire pump requirements of NFPA 20.

11.14.8 Foam Concentrate Supply.

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

11.14.8.2 The quantity of high-expansion foam concentrate shall be calculated for a 12-minute discharge at the water flow rate as determined in 11.14.7.5.3.

11.14.8.3 A reserve supply of foam concentrate shall be provided in accordance with 4.3.2.5.2 of NFPA 11.

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

11.14.9 Foam Concentrate Pumps.

11.14.9.1 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 shall be capable of being 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).

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

11.14.9.3 Controllers for foam concentrate pumps shall be as follows:

(1) For electric-drive foam concentrate pumps, a listed full-service fire pump controller shall be used.
(2) For diesel engine–drive foam concentrate pumps, a listed fire pump controller shall be used.

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

11.14.10 Detection and Actuation System Design.

11.14.10.1 General. Actuation systems shall be provided with complete circuit supervision and shall be arranged in accordance with 11.14.15.

11.14.10.2 Foam Fire Protection Systems.

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

11.14.10.2.2 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 positions to facilitate early system actuation in the event of a fire.

11.14.11 Hand Hose Systems.

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

11.14.11.2 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 designed to be operated simultaneously.

11.14.11.3 Foam-Water Hand Hose Systems.

11.14.11.3.1 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 defueled aircraft.

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

11.14.11.3.3 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.

11.14.11.3.4 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 a diameter to provide a minimum flow of 227 L/min (60 gpm).

11.14.11.3.5 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.

11.14.11.3.6 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.

11.14.11.3.7 The minimum supply of foam–liquid concentrate shall be calculated 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.

11.14.11.4 Water Hand Hose Systems.

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

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

11.14.12* Water Supply.

11.14.12.1 The total water supply shall be designed to meet the demand of the protection systems as described in 11.14.1(1), 11.14.1(2), 11.14.2(1) through 11.14.2(3), 11.14.3, and 11.14.4 and the requirements for hose stream and other equipment as determined in 11.14.11. Water shall be available in the quantity and pressure required to supply the maximum number of discharge devices designed to operate simultaneously.

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

11.14.12.3 Hand Hose Systems. The water supply for hand hose systems shall be capable of satisfying the requirements of 11.14.11. 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.

11.14.12.4 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.

11.14.13 Fire Pumps.

11.14.13.1 Fire pumps shall be installed in accordance with NFPA 20 and in accordance with the provisions of 11.14.13.2 through 11.14.13.7.

11.14.13.2 The total pumping capacity shall be provided using fire pumps of equal capacity.

11.14.13.3 No fewer than two fire pumps shall be provided.

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

11.14.13.5 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.

11.14.13.6 Where pressure loss is used as the starting sequence for fire pumps, a small auxiliary pressure maintenance pump or other suitable means to maintain normal system pressures shall be provided.

11.14.13.7 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.

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

11.14.13.9 Acceptance Tests.

11.14.13.9.1 The tests in 11.14.13.9.2 through 11.14.13.9.8 shall be performed prior to final acceptance of any fire protection system in an aircraft hangar.

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

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

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

11.14.13.9.5 Any proportioner not tested under the requirements of 11.14.13.9.4 shall be individually tested with foam concentrate to determine concentrate percentage.

11.14.13.9.6 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, and percent concentration, are satisfactory.

11.14.13.9.7 Low-expansion and high-expansion foam protection systems shall be examined visually to determine that they have been installed correctly. 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 identified, and operating instructions shall be prominently posted.

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

11.14.13.10 Final Approval. The installing company shall furnish a written statement that the work has been completed in accordance with 11.14.6 and tested in accordance with the provisions of 11.14.13.9.

11.14.14 Wheeled and Portable Extinguishers.

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

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

11.14.14.3 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.

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

Chapter 12 Paint Hangars

12.1 Construction.

12.1.1 Paint hangars shall be constructed in accordance with Chapter 7 of this standard.

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

12.2 Fire Protection.

12.2.1 The protection of aircraft paint hangars shall be in accordance with either Chapter 8 or Chapter 9 of this standard, whichever is applicable.

12.2.1.1 The design area of the closed-head water sprinkler system shall not be required to be increased for ceiling slope.

12.2.1.2 The design area of the closed-head water sprinkler system shall not be required to be increased for preaction systems.

12.2.2 The protection of an aircraft paint hangar housing defueled aircraft shall be in accordance with the provisions of NFPA 13 for an extra hazard Group 2 occupancy.

12.3 Ventilation.

12.3.1 The ventilation system in a paint hangar shall be in accordance with the ventilation provisions of NFPA 33 and 12.3.2 through 12.3.4 of this standard.

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

12.3.3 Recirculation of a portion of the exhaust stream back into the hangar shall be permitted, provided the recirculation provisions of NFPA 33 for booths and rooms and the requirements of 12.3.3.1 and 12.3.3.2 are met.

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

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

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

12.4 Electrical Equipment.

12.4.1 Electrical equipment in a paint hangar shall be in accordance with Article 513 and Article 516 of *NFPA 70* and 12.4.2 through 12.4.4 of this standard.

Δ **12.4.2** The area within 3 m (10 ft) horizontally from aircraft surfaces from the floor to 3 m (10 ft) above the aircraft shall be classified as Class I, Division 1 or Zone 1. The area horizontally from aircraft surfaces between 3.0 m (10 ft) and 9.0 m (30 ft) from the floor to 9.0 m (30 ft) above the aircraft surface shall be classified as Class I, Division 2 or Zone 2. [**70**:513.3(C)(2)]

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

12.4.4* In addition to the grounding requirements in Chapter 7, grounding facilities shall be provided for the paint or other flammable or combustible liquid application system and the application system operator.

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

Chapter 13 Inspection, Testing, and Maintenance

13.1 Fire Protection Systems.

13.1.1 Inspection, testing, and maintenance of fire protection systems in aircraft hangars shall be performed in accordance with NFPA 4, NFPA 11, NFPA 25, *NFPA 70*, *NFPA 72*, or NFPA 80 as applicable and as supplemented by Table 13.1.1.

13.1.1.1 The 5-year discharge test for piping required in Table 13.1.1 shall not be required if an internal inspection in accordance with NFPA 25 indicates that the pipe is in good condition and free of obstructions, mechanical damage, leakage, and corrosion.

N **13.1.2** The requirements of Chapter 13 shall be retroactive and apply to existing systems as well as new systems.

N **13.1.3** The most current edition of the applicable codes, per Chapter 2, shall be used for inspection, testing, and maintenance.

N **13.1.4** The testing performed shall be compared to the original performance specifications of the system to validate compliance and verify that the tested components function as originally designed.

N **13.1.5*** All the necessary precautions shall be put in place prior to system testing to prevent damage to the facility during the testing.

13.1.6 Records of inspections, testing, and test results shall be maintained by the hangar owner or operator, as well as the contractor conducting the testing.

N **13.1.7 Initial System Testing.**

N **13.1.7.1** Initial open-head (deluge) system testing shall be conducted by discharging water into the hangar area to verify that all the system components function as originally designed, followed by discharging the foam-water solution, unless the AHJ only permits the use of water.

N **13.1.8 Annual System Testing.**

N **13.1.8.1** Where required by Table 13.1.1, annual system testing shall be conducted by qualified personnel as approved by the AHJ.

N **13.1.8.2** Fire pump testing shall be performed in accordance with NFPA 25.

N **13.1.8.3** Corrective actions shall be taken if required.

N **13.1.9 5-Year System Testing.**

N **13.1.9.1** Where required by Table 13.1.1, 5-year discharge system testing shall be performed by trained and qualified personnel.

N **13.1.9.2** Where required by Table 13.1.1, 5-year fire protection testing shall be performed as required by NFPA 4 to confirm all the integrated fire protection systems operate as required.

N **13.1.9.3** The foam system shall be tested with the test connection using a foam solution to verify the actual foam concentrate proportioning rate required for the system demand or as recommended by the manufacturer of the proportioning equipment.

N **13.1.9.4** Open-head deluge system testing shall be conducted by discharging water through the test connection, if available, or into the hangar area to verify that all the system components function as originally designed.

N **13.1.9.5** Piping, deluge valve, hose station, monitor nozzle, and foam generator testing shall be permitted to be conducted by discharging water into the hangar area through all the discharge devices and by verifying the proper coverage of the protected space.

N **13.1.9.6** The foam concentrate pumps, concentrate control valve, proportioning device, and other system components shall be permitted to be tested with a test connection using a foam-water solution at the designed discharge rates to verify the actual foam concentrate proportioning rate.

N **13.1.9.7** 5-year foam system testing shall include verification of the actual foam concentrate proportioning rate.

N **13.1.9.8** Closed-head foam-water sprinkler system testing shall be conducted with water only through the test connection to verify the adequacy of the water supply at the required system demand.

N **13.1.9.9** The foam concentrate utilized shall be replenished.

N **13.1.9.10** Corrective action shall be taken where required.

Δ Table 13.1.1 Inspection and Testing of Hangar Fire Protection Systems

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

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

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

[2]Churn test.

[3]The intent of this test is to discharge foam through a test header or the discharge device.

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

[5]Test is permitted to be performed with water only unless foam is required by the AHJ.

Δ Chapter 14 Defueled Aircraft Hangars

14.1 General. This chapter shall apply to those hangars housing aircraft that have never been fueled or have had the fuel removed to comply with the definition for defueled aircraft in Chapter 3.

14.2 Construction. Defueled aircraft hangars shall be constructed in accordance with Chapter 7 of this standard, and as modified herein.

14.2.1 Internal Separations.

14.2.1.1 Shops, offices, and parts storage areas shall be permitted to be located in the aircraft storage and servicing area without a fire-rated separation.

14.2.1.2 Attached, adjoining, or contiguous structures, such as a lean-to, shop, office, or parts storage area shall be permitted without a fire-rated separation.

14.2.1.3 Internal separations between the aircraft storage and servicing area and shops, offices, and parts storage areas shall be of noncombustible or limited combustible construction.

14.2.2 Columns. Unprotected columns in aircraft storage and servicing areas shall be permitted.

14.2.3 Floors. Hangar floors in aircraft storage and servicing areas without trench drainage systems shall be permitted.

14.2.4 Heating and Ventilating.

14.2.4.1 Heating, ventilating, and air-conditioning equipment shall be permitted to employ the use of open flames or glowing elements.

14.2.4.2 Heating plants that are fired with gas, liquid, or solid fuels shall not be required to be separated from the aircraft storage and servicing area by fire resistance-rated partitions.

14.2.4.3 Heating, ventilating, and air-conditioning systems employing recirculation of air within aircraft storage and servicing areas shall be allowed to have supply and return air openings at or near floor level.

N **14.2.5 Clear Space Distance Requirements Around Hangars.** The requirements of Section 7.4 shall not apply to aircraft hangars storing or servicing defueled aircraft.

N **14.2.6 Draft Curtains.** The requirements of Section 7.18 shall not apply to aircraft hangars storing or servicing defueled aircraft.

14.3 Lighting and Electrical Systems.

14.3.1 Lighting and electrical systems shall comply with the provisions of *NFPA 70*.

14.3.2 Main electrical distribution panels, metering equipment, and similar electrical equipment shall not be required to be separated from aircraft storage and servicing areas by fire-rated partitions.

14.4 Grounding Facilities for Static Electricity. Aircraft storage and servicing areas shall be provided with grounding facilities in accordance with this standard.

14.5 Protection of Defueled Aircraft Hangars.

14.5.1 This section shall apply to all Group I and Group II hangars, and Group IV hangars with fire areas greater than 1115 m^2 (12,000 ft^2).

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

14.5.3 Sprinkler piping shall be hydraulically sized in accordance with NFPA 13. The maximum area covered by a single sprinkler system shall not exceed 3716 m^2 (40,000 ft^2).

14.5.4 Sprinklers shall be spaced in accordance with NFPA 13 or in accordance with their listings.

14.5.5 Where open hangar doors result in an obstruction to the distribution of water from the hangar sprinkler systems, additional sprinklers shall be provided beneath the doors to ensure required floor coverage.

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

14.5.6.1 An outside hose stream demand of 1893 L/min (500 gpm) shall be included in all hydraulic calculations.

14.5.6.2 The design area of the closed-head water sprinkler system shall not be required to be increased for ceiling slope.

14.5.6.3 The design area of the closed-head water sprinkler system shall not be required to be increased for preaction systems.

14.5.7 Sprinklers shall be control mode and have a minimum nominal K-factor of K-80 (K-5.6). Suppression mode sprinklers shall be allowed when the hangar occupancy is covered by other applicable NFPA standards (e.g., the storage protection provisions in NFPA 13). Sprinklers shall be listed for their application, and designed and installed in accordance with NFPA 13 or their listings.

14.5.8 Sprinklers having a temperature rating of 79.4°C (175°F) shall be used. Sprinklers having a temperature rating of 93.3°C (200°F) shall be permitted in areas subject to high ambient temperatures.

14.5.9 Acceptance tests for sprinkler systems shall be in accordance with NFPA 13.

14.5.10 Water hand hose systems shall not be required in aircraft storage and servicing areas, shops, offices or non-aircraft storage areas, except where required by other NFPA standards.

14.5.11 The total water supply shall be available in sufficient quantity and pressure to satisfy the demand created by the combination of the sprinkler system and the requirements for hose streams. This supply shall be available for a minimum duration of 60 minutes.

14.6 Spray Application of Flammable and Combustible Liquids.

14.6.1 Paint spray application booths, installed and protected in accordance with NFPA 33, shall be allowed in the hangar storage and servicing area.

14.6.2 Protection for aircraft hangars used for the spray application of flammable and combustible liquids shall be in accordance with this standard and NFPA 410.

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

14.7 Portable Extinguishers.

14.7.1 Portable extinguishers shall be provided in accordance with NFPA 10.

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

14.7.3 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.

14.8 Protection System Alarms. In addition to local alarm service, water flow and fire detection alarms shall be transmitted to a constantly attended location, in accordance with *NFPA 72*.

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.

N **A.1.1.3** This standard is intended to apply to fuels such as gasoline, aviation gasoline (AVGAS), diesel fuel, jet fuel A, jet fuel B, and variants of these fuels. It is not intended to apply to gaseous or solid fuels.

A.1.2 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.

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

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

A.3.2.3 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.3.3.3 Aircraft Storage and Servicing Area. Wherever the term *storage and servicing* is used in this document, it is intended to imply that it is the area where aircraft are stored, serviced, or both.

A.3.3.5 Defueled Aircraft. The intent of this section is that fuel should be removed to limit the single event spill potential. Option 1 is presented to eliminate the need for draining fuel tanks/cells when the fuel systems are capable of removing almost all fuel within the tank/cell via only the basic defueling process. Option 2 is for aircraft whose basic defueling process leaves a significant amount of fuel (greater than 1 percent) trapped in the tanks/cells. The intent of the phrase "greatest extent possible" is for fuel to be removed via normal servicing methods, to include low-point draining of all fuel tanks/cells, in accordance with aircraft-specific technical data, without unnecessary disassembly of the aircraft. The typical defueling process is performed with a fuel truck, cart, or bowser process, usually through the aircraft's refuel port. In addition to defueling, the aircraft should be drained via fuel system low-point drains (i.e., pencil drained) to remove additional fuel. To adequately remove as much fuel as possible, settling time should be included prior to final low-point draining to ensure that little or no spill probability remains.

N **A.3.3.12 Liquid Drainage Floor Assembly.** In cases where the liquid is ignited, the system is designed to minimize the spill area and reduce the overall size of the fire until the flow of liquid is stopped, and/or fire-fighting measures are initiated. The structural integrity of the floor should not be compromised by an ignition scenario.

A.3.3.14 Paint Hangar. As prescribed in NFPA 410, painting operations in maintenance and storage hangars are limited to 80 ft^2 in a 2-hour period. For purposes of this standard, this applies to the application of any flammable or combustible liquids.

N **A.3.3.15 Professional Engineer.** An individual who is a registered professional engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience.

A.3.3.18 Tail Height. For overall height of various transport-type aircraft, see Table A.3.3.18.

A.3.3.20 Wing Area. See Table A.3.3.18.

N **A.4.2.1** The fire risk analysis should be evaluated by the stakeholders. See NFPA 551 for additional guidance.

Table A.3.3.18 Gross Wing Area and Overall Height for Selected Aircraft

Aircraft	Gross Wing Area		Overall Height	
	m^2	ft^2	m	ft–in.
Airbus A-380*	830.0	8920	24.1†	79–0
Antonov An-124*	628.0†	6760	21.0†	69–2
Lockheed L-500-Galaxy*	576.0†	6200	19.8†	65–1
Boeing 747*	541.1†	5825	19.4†	63–8
Airbus A-340-500, -600*	437.0†	4703	16.7†	54–11
Boeing 777*	427.8†	4605	18.5†	60–9
Ilyushin II-96*	391.6†	4215		
DC-10-20, 30*	367.7†	3958	17.7†	58–1
Airbus A-340-200, -300, A-330-200, -300*	361.6†	3892	16.7†	54–11
DC-10-10*	358.7†	3861	17.7†	58–1
Concorde*	358.2†	3856	12.2†	40–0
Boeing MD-11*	339.9†	3648	17.6†	57–9
Boeing MD-17*	353.0†	3800	16.8†	55–1
L-1011*	321.1†	3456	16.9†	55–4
Ilyushin II-76*	300.0†	3229	14.8†	48–5
Boeing 767*	283.4†	3050	15.8†	52–0
Ilyushun IL-62*	281.5†	3030	12.3†	40–6
DC-10 MD-10	272.4	2932		
DC-8-63, -73	271.9	2927		
DC-8-62, -72	271.8	2926		
DC-8-61, 71	267.8	2883		
Airbus A-300	260.0†	2799	16.5†	54–3
Airbus A-310	218.9†	2357	15.8†	51–10
Tupolev TU-154	201.5†	2169	11.4†	37–4
Boeing 757	185.2†	1994	13.5†	44–6
Tupolev TU-204	182.4†	1963	13.9†	45–7
Boeing 727-200	157.9†	1700	10.4†	34–0
Lockheed L-100J Hercules	162.1†	1745	11.6†	38–3
Yakovlev Yak-42	150.0†	1614	9.3†	32–3
Boeing 737-600, -700, -800, -900	125.0†	1345	12.5†	43–3
Airbus A-318, A-319, A-320, A-321	122.6†	1319	11.8†	38–8
Boeing MD 80	112.3†	1209	9.0†	29–7
MD 90			9.3†	30–7
Gulfstream V	105.6†	1137	7.9†	25–10
Boeing 737-300, -400, -500	105.4†	1135	11.1†	36–6
Tupolev TU-334, TU-354	100.0†	1076	9.4†	30–9
BAC 1-11-500	95.8†	1031	7.5†	24–6
NAMC YS-11	94.8†	1020	8.9†	29–5
Fokker 100, 70	93.5†	1006	8.5†	27–10
BAC 1-11-300, -400	93.2	1003	7.5†	24–6
Boeing 717	93.0†	1001	8.8†	29–1
DC-9-30	93.0†	1001	8.4†	27–6
Boeing 737-200	91.0†	980	11.3†	37–0
Gulfstream IV	88.3†	950	7.4†	24–5
DC 9-10	86.8†	934	8.4†	27–6
BAe 146, RJX-70, -85, -100	77.3†	832	8.6†	28–3
Fokker 50, 60	70.0†	753	2.7†	27–3
Canadair RJ-700	68.6†	738	7.6†	24–10
Dash 8 Q400	63.0†	679	7.5†	24–7
ATR 72	61.0†	656	7.6†	25–1

(continues)

Table A.3.3.18 *Continued*

Aircraft	Gross Wing Area		Overall Height	
	m^2	ft^2	m	ft–in.
Airtech CN-235	59.1†	636	8.2†	26–10
Saab 2000	55.7†	600	7.7†	25–4
Canadair RJ-100, -200	54.5†	587	6.2†	20–5
ATR 42	42.5†	586	7.6†	24–10
Dash 8 Q100, Q200	54.3†	585	7.5†	24–7
Embraer ERJ-135, -145	51.1†	550	6.9†	22–1
Cessna 750	48.9†	527	5.8†	18–11
Cessna 680	47.9†	516	5.5†	19–2
Saab 340	41.8†	450	6.9†	22–1
Embraer EMB-120	39.4†	424	6.3†	20–10
Bell Boeing V-22	39.5†	382	6.6†	21–9
Britten-Norman BN2	30.2†	325	4.2†	13–8
Cessna 650	28.9†	312	5.1†	16–9
Beech 1900	28.8†	310	4.7†	15–6
Beech King Air C90	27.3†	294	4.3†	14–3

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

N **A.4.2.3** Protection for aircraft storage and service areas should be specific to the nature and anticipated fire risks of each hangar facility. NFPA 551 can be used as a reference guide for conducting and evaluating fire risk assessments.

N **A.5.3** It is essential that design professionals recognize the possibility of fire in an aircraft hangar. Licensed design professionals who develop performance-based design documents should be well versed in the science of fire, the effects of fire on aircraft hangars and hangar operations, and options for mitigation of the risk presented by fire in an aircraft hangar to persons, equipment, and operations.

N **A.5.4** The SFPE *Guidelines for Peer Review in the Fire Protection Design Process* provides guidance concerning the peer review process for fire protection designs.

N **A.5.7.4** The SFPE's *Engineering Guide: Performance-Based Fire Protection* is a recommended guide that should be used in the development of a Design Brief and Performance-Based Design Report.

N **A.5.7.4.1** The intent of the permitted deviation would be stated in the Design Brief or an informational annex of the Design Brief. A deviation might be permitted as long as the equivalent performance features are maintained.

N **A.5.7.4.3** An inspection, testing, and maintenance program is recommended to be provided to the responsible hangar owner or operator and made readily available.

A.7.2.1 Building construction types are defined in NFPA 220. See Annex B for more information.

A.7.2.2 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 7.3.1.

A.7.3.1 Fire barrier 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

A.7.3.3 Shops, office, and storage areas should be in separate, detached buildings. Workshops, offices, and storage areas having their own roof coverings and built within aircraft storage or servicing areas should have watertight roof deck coverings.

A.7.4.2.3 See also NFPA 80.

A.7.5.2 These special hazards include, but are not limited to, spray painting or doping areas, flammable liquid storage or mixing rooms, and so forth.

A.7.6.1 Such classifications of roof coverings are determined when tested in accordance with ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, or UL 790, *Test Methods for Fire Tests of Roof Coverings*.

A.7.6.3 Construction types will dictate the need for sprinkler protection in these spaces.

A.7.7.3 Additional guidance pertaining to fixed water spray systems can be found in NFPA 15. This information can also be used in the design of foam-water systems and when extension of discharge devices from the overhead sprinkler system is used. The design of such protection should take into account factors such as the shape of the column, wetting of lower sprinklers, obstructions, and type of discharge device.

A.7.7.3.4 The locations of discharge devices should preferably be on alternate sides of the columns. The wetted surface of a

structural member is defined as one side of the web and the inside surface of one side of the flanges.

A.7.8.3 Preplanning should ensure availability of necessary auxiliary equipment such as tractors, cables, grapnels, and so forth, where manual operation is either impossible or too slow to allow prompt aircraft removal.

A.7.8.4 The coldest weather temperature that is used to determine the need for heating should be based on the lowest mean temperature for one day, as shown in Figure A.7.8.4.

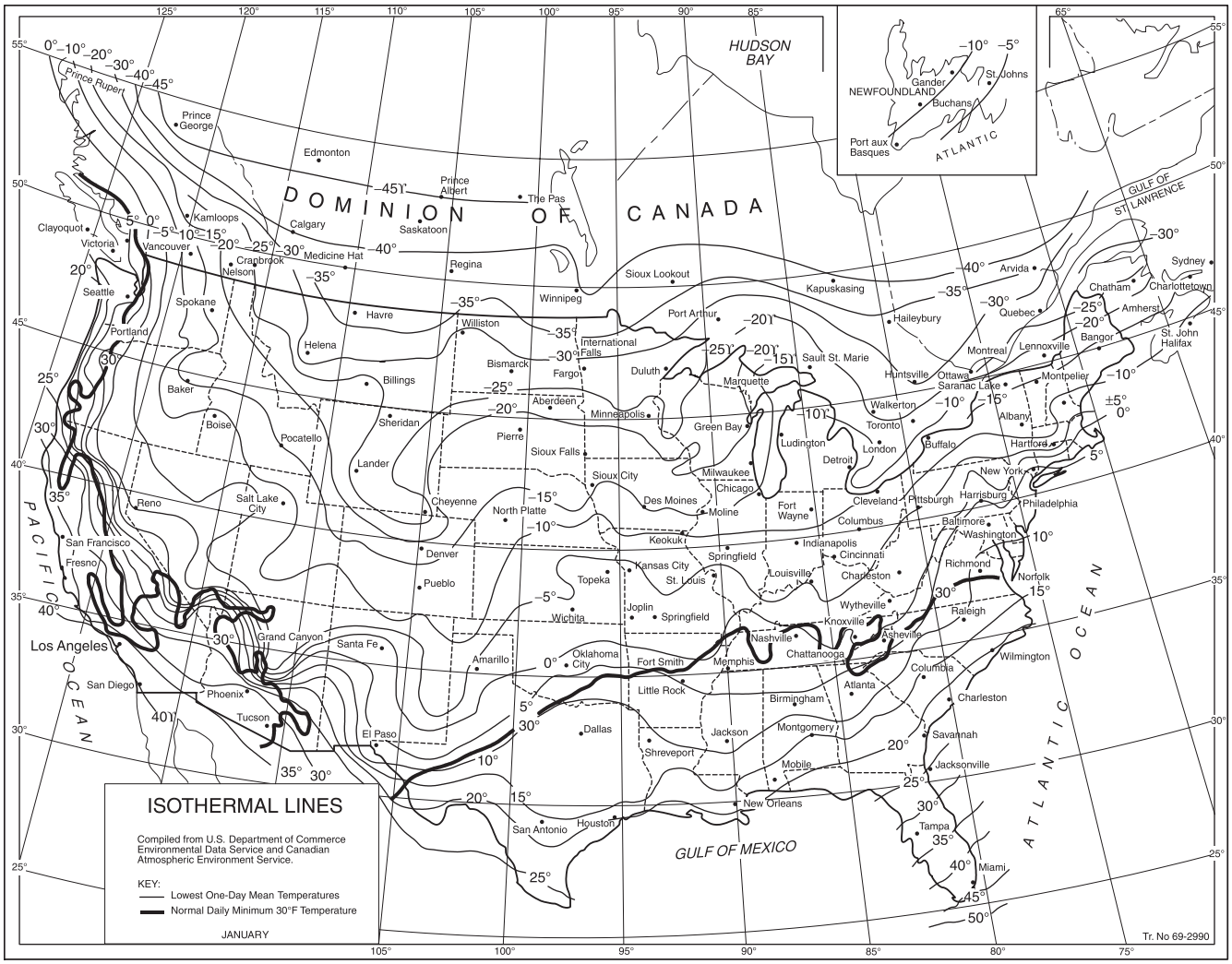
A.7.10.1 Landing gear pits, ducts, and tunnels located beneath the hangar floor should be avoided if possible because of the danger of accumulation of flammable liquids or vapors; where their use is essential, the protection measures specified in Section 7.10 should be followed. For floor drainage, see 7.12.2.

A.7.10.5 Sensors should be installed in accordance with the manufacturer's instructions, and close attention paid to the recommended sensor spacing.

A.7.10.7 The venting arrangements will depend on the design of the pits, elevating platforms, and means of access. It might be necessary for part of the platform surface to be grated or perforated to provide adequate explosion venting area. The general principles in NFPA 68 should be followed.

A.7.10.8 Consideration should be given to the selection of an extinguishing agent that could also be used as a means of inerting the pit in the event that flammable vapors are present concurrent with the loss of use of the ventilation system due to power failure, maintenance, or other causes.

A.7.12.2.2 Aircraft hangars also might require floor trench drainage systems to effectively dispose of water used for cleaning aircraft and hangar floor surfaces and water accumulation from possible flooding due to high groundwater tables, and to drain away water discharged from the fire protection equipment provided within the structure. Reference can be made to NFPA 415 for information on drainage systems and to Annex A of NFPA 15 for information on drainage equipment and arrangements.



Source: Compiled from United States Weather Bureau records.
For SI units, °C = ⅝ (°F± 32); 1 mi = 1.609 km.

Δ FIGURE A.7.8.4 Lowest Mean Temperature Map.

A.7.13.1 It is recommended that hangar heating, ventilating, and air-conditioning equipment fired with gas, liquid, or solid fuel be located in a fire-resistive or noncombustible detached building wherever possible.

A.7.13.4 Personnel should be fully instructed that in the event of a serious gasoline or similar flammable liquid spill on the hangar floor, the fans should be shut off.

A.7.14.2 See also 7.8.2 for power supply to doors accommodating aircraft.

A.7.15 All aircraft hangars should be surveyed to determine the need for approved lightning protection. Where installed, such systems should be listed. See NFPA 780.

A.7.16.1 As low a resistance as possible should be secured and maintained. Ten thousand ohms is a practical recommended maximum where determined by standard procedures. For further details on this subject, see NFPA 407 and NFPA 77.

A.7.16.3 Speedometer, preformed steel, or equivalent cable will minimize danger of employee hand injury.

A.7.18 *Depth of Draft Curtains.* Draft curtains should extend down from the roof or ceiling of aircraft storage and servicing areas not less than one-eighth of the height from the floor to the roof or ceiling. Under curved or sloping roofs extending to grade level or close to grade level, draft curtains need not be continued below 4.8 m (16 ft) from the floor.

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

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

A.7.18.3 The reason for limiting a draft curtain area to 697 m^2 (7500 ft^2) is to improve detection and sprinkler response times, not to limit the fire suppression system size.

A.8.2.1.1 It is highly important and expedient that all applicable areas of responsibility, such as those that cover adequacy of water supplies, design, suitability of agent, application rates used, area covered, testing, flushing, approvals, and so forth, be clearly defined in the contract documents. This is important where there is shared responsibility for various portions of the fire protection systems.

A.8.2.2.2 The manual control valve for each individual sprinkler system should be located outside aircraft storage and servicing areas.

A.8.2.2.7 This provision is for the purpose of addressing obstructions that can be caused by hangar door positions. It is not intended to address interference due to wind.

A.8.2.3.1 Supplementary protection systems for hangars containing several aircraft, each having a wing area less than 279 m^2 (3000 ft^2), can be warranted. Such systems are recommended under the following conditions:

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

A.8.2.3.2 In general, the specified floor area would be the area under the wings and wing center sections of the aircraft. Configuration of aircraft and positioning of aircraft and ground equipment within an aircraft storage and servicing area can compromise the effectiveness of any supplementary protection systems. Original design and testing of such systems should anticipate obstructions on the floor (such as those created by working platforms) in providing protection over the specified floor areas. The discharge from overhead hangar protection systems might not protect the aircraft from a fire in the shielded areas beneath the wings and the wing center sections. The supplementary system is intended to provide protection in those shielded areas by controlling such fires quickly and preventing extensive damage to the aircraft. The area to be protected depends on the configuration and the number of aircraft and their positioning arrangements, as well as the location of permanent service structures within the aircraft maintenance and servicing area. Protection of the entire aircraft maintenance and servicing area could be required because of the variety of possible aircraft positioning arrangements.

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

A.8.2.3.3.2 Experience has shown that the mechanism for manual operation of automatic oscillating monitor nozzles is a major factor in the failure rate of these devices. A large percentage of these failures have been due to operators failing to change the device from the manual to the automatic mode after testing and maintenance. The most reliable device is considered to be one that is designed for automatic operation only and that has no manual operating mode.

A.8.2.3.4.2 To achieve the design principles, the rate of foam rise should be at least 0.9 m/min (3 ft/min) beneath the aircraft wings and wing center section. With large shielded areas, a higher rate of foam rise could be required. The foam generators should be installed and positioned in such a way that the flow of foam on the floor is directed to areas beneath the aircraft wings and wing center section. If the fire spreads to the aircraft interior, it could seriously damage or destroy the aircraft unless an automatic fire extinguishing system is also provided inside the aircraft cabin. If generators are located on the exterior of the hangar, the possible hazards of freezing water on the generator screens should be considered. The discharge of high-expansion foam in the hangar space can handicap visibility for manual fire fighting.

N **A.8.2.3.4.3** See A.9.5.3.