NFPA 423

Standard for

Construction and Protection of Aircraft Engine Test Facilities

2004 Edition

This edition of NFPA 423, *Standard for Construction and Protection of Aircraft Engine Test Facilities*, was prepared by the Technical Committee on Airport Facilities and acted on by NFPA at its May Association Technical Meeting held May 23–26, 2004, in Salt Lake City, UT. It was issued by the Standards Council on July 16, 2004, with an effective date of August 5, 2004, and supersedes all previous editions.

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Origin and Development of NFPA 423

The Sectional Committee started work on this standard in 1972. It was first submitted to the Association at the 1975 Fall Meeting but was returned to committee for coordination with the NFPA Committee on Fire Tests. The 1977 edition contained the results of that coordination effort. The standard was reconfirmed in 1983. The 1989 edition was a complete revision of the 1983 edition, and the 1994 and 1999 editions were partial revisions of the standard.

The standard was revised to comply with the NFPA *Manual of Style* for this edition.

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

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

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

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard establishes the minimum fire safety practices regarding location, construction, services, utilities, fire protection, operation, and maintenance of aircraft engine test facilities.

1.1.2 These facilities include test cells and test stands.

1.1.3 This standard does not apply to engines and engine accessories or to engine test facilities where fuels other than hydrocarbon fuels are used.

1.2 Purpose.

The purpose of this standard is to provide aircraft engine test facilities with a reasonable degree of life safety and protection from fire, based on sound engineering principles, test data, and field experience.

Chapter 2 Referenced Publications

2.1 General.

The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications.

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

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

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

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

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2000 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 2004 edition.

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

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

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

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

NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 2002 edition.

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

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

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

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

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

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

NFPA 75, *Standard for the Protection of Information Technology Equipment,* 2003 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 2003 edition.

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

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

2.3 Other Publications.

2.3.1 ASME Publication.

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B31.1, *Code for Power Piping*, 1998.

Chapter 3 Definitions

3.1 General.

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

3.2 NFPA Official Definitions.

3.2.1* **Approved.** Acceptable to the authority having jurisdiction.

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

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

3.2.4 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1 Control Room. See 3.3.7.1.

3.3.2 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. [**409:**3.3]

3.3.3 Engine Rundown Time. The time required for an engine under test to reduce its rotational speed to 10 percent of its speed at full power (100 percent).

3.3.4 Engine Test Cell. The space in which a test engine is installed on a thrust stand during a test and is totally enclosed by permanent building components, except where the enclosure is breached by air ducts, services, access ports, or doors.

3.3.5 Engine Test Facility. An integrated system that includes a building(s), a structure(s), space, and services used to test aircraft engines within a test cell or on a test stand.

3.3.6 Engine Test Stand. A space for testing an aircraft engine, such as a test cell, except that the engine test space is not totally enclosed within a permanent building.

3.3.7 Room.

3.3.7.1 *Control Room.* A room with instrumentation and devices to control, measure, record, or observe test cell and engine operation and performance.

3.3.7.2 *Support Room.* An enclosure or area, excluding the test cell or control room, that is an integral part of engine testing, including fuel-handling rooms, hydraulic rooms, preparation areas, and mechanical/electrical rooms.

Chapter 4 Construction and Internal Subdivisions

4.1 Construction of Aircraft Engine Test Facilities.

4.1.1 Test cell walls, ceilings, and floor assemblies shall be at least Type II (222) construction as defined in NFPA 220.

4.1.2 Materials of construction, such as thermal or acoustic insulation used within the test cell, shall be noncombustible as defined in NFPA 220.

4.1.3 Belowgrade Limitations.

4.1.3.1 Engine test facilities shall be constructed without basements or belowgrade areas other than those recesses in the floor necessary to accommodate sump pumps, drainage facilities, or lifting platforms.

4.1.3.2 In existing facilities, all basement areas, tunnels, or other belowgrade spaces shall be addressed as follows:

(1) The areas shall be eliminated.

(2) The fuel-handling system shall be segregated, drainage shall be provided, and the basement area shall be cut off so as to eliminate the possibility of flammable vapors collecting in the basement area or a spill of flammable or combustible liquids discharging into a basement area.

4.1.4* An explosion hazard analysis of the engine test cell shall be performed to determine whether an explosion hazard capable of compromising the integrity of the structure exists.

4.1.5 If the hazard analysis required in 4.1.4 indicates that an explosion hazard exists, one of the following shall be incorporated:

(1) Explosion venting

(2) Explosion suppression system

(3) Explosion-limiting construction

4.2* Internal Subdivisions of Aircraft Engine Test Facilities.

Engine test cells, fuel handling areas, and hydraulic rooms shall be separated from adjacent areas by construction having a minimum fire rating of 2 hours.

Chapter 5 Service and Utilities

5.1 General Safeguards.

5.1.1* Where objects, such as supports, nuts, and bolts, are located such that they might be ingested into an aircraft turbine engine, one of the following criteria shall be met:

(1) The objects shall be secured by safety wires, tack welding, adhesive, or approved aircraft-type locking devices.

(2) An inlet screen of a design that protects an engine from foreign object damage shall be used.

5.1.2 All materials likely to become exposed to fuels, oils, or hydraulic fluids shall be resistant to deterioration from the fuels being used.

5.2 Drainage Systems.

5.2.1* Drainage systems shall be provided for engine test cells and support rooms containing flammable liquid– or combustible liquid–handling systems to reduce fire and explosion hazards.

5.2.2 Floors subject to possible spillage of flammable or combustible liquids shall be pitched a minimum of 1 percent toward the drain(s), which shall be located to minimize fuel spread and exposure to equipment.

5.2.3 Curbs, ramps, or drain trenches shall be installed to prevent the flow of flammable or combustible liquids into adjacent rooms or buildings.

5.2.4* Drainage systems shall be designed and installed to provide a capacity that prevents a buildup of flammable or combustible liquids and water over the drain inlet under the maximum possible water discharge rate.

5.2.5* Drain traps shall have a trap seal water head.

5.2.5.1 In test cells, the seal water head shall be greater than the expected difference between the test cell operating pressure and atmospheric pressure.

5.2.6 Drain piping and joints shall be resistant to deterioration from fuels, engine oil, and aircraft hydraulic system fluids.

5.2.7 A common or separate oil separator(s) shall be provided in drains from the engine area, the exhaust plenum area, and support rooms.

5.2.7.1 Separator systems shall discharge flammable or combustible liquid products to an approved, safely located tank, cistern, sump, or pond that is away from or cut off from the engine test facility.

5.2.7.2 In aircraft engine test facilities protected by a fire protection system utilizing water, a bypass shall be provided around the separator to allow for emergency direct disposal of water and flammable liquids to an approved location.

5.2.8 Maintenance checks and flushing shall be conducted on all drains and oil separators at least annually to ensure that they are clear of obstructions.

5.3 Electrical Requirements.

5.3.1 Any pits, depressions, or other below-floor-level locations of engine test cells, fuel-handling areas, and hydraulic rooms shall be classified as Class I, Division 1 hazardous locations as defined in Article 500 of NFPA 70, and such classification shall extend up to floor level.

5.3.2 The engine test cell, including intake and exhaust plenums, fuel-handling areas, and hydraulic rooms, shall be classified as a Class I, Division 2 hazardous location as defined in Article 500 of NFPA 70, and such classification shall extend to a level 0.46 m (18 in.) above the floor.

5.3.3* All wiring and equipment that are installed or operated within any of the hazardous locations specified in Section 5.3 shall comply with applicable provisions of Article 501 of NFPA 70.

5.3.4 When wiring is located in vaults, pits, or ducts below the test cell floor, drainage shall be provided.

5.3.5 All wiring in the exhaust plenum that is not located within the hazardous location as specified in 5.3.2 shall be installed in rigid conduit.

5.3.6 All other test facility wiring that is not located within a hazardous location shall meet the requirements of Chapter 3 of NFPA 70.

5.3.7 All wiring not enclosed in raceways, such as harness wires connecting to the engine, shall be supported, laced, or banded to minimize wear from air velocity and vibration.

5.3.8* A means shall be provided at the control console to shut off all electric power other than emergency circuits to the test cell in the event that the engine disintegrates or fuel leaks develop during operation.

5.4 Heating and Cooling.

5.4.1* Heating and cooling systems shall be arranged to achieve all of the following:

(1) Reduction of exposure of vital system elements to fire, explosion, and damage by metal

(2) Elimination of the introduction of ignition sources by components of heating systems

(3) Minimization of the passage of fire through ductwork

(4) Elimination of pockets in which flammable vapors can accumulate

5.4.2* Steam, hot water, or indirect warm air heating systems shall be used for general room or building heating in areas where flammable or combustible liquids or flammable gases are handled.

5.4.2.1 Where flammable or combustible liquids or heavier-than-air flammable gases are used, return openings in hot air systems shall be located a minimum of 3 m (10 ft) above the floor.

5.4.2.2 A remote control station shall be provided to shut down the warm air heating system.

5.4.3* Cooling systems utilizing flammable refrigerants shall not be installed or used within the test cell.

5.4.4* Where direct-fired inlet air preheaters are essential to simulate hot inlet air conditions, the following criteria shall be met:

(1) Fuel safety controls as specified in NFPA 86 shall be provided.

(2) Interlocks shall be provided to prevent ignition of a direct-fired system until adequate airflow has been established within the test cell or the engine is running.

5.4.5 Direct-fired or indirect-fired heaters for heating test cell inlet air shall be designed in accordance with applicable sections of NFPA 31, NFPA 54, and NFPA 58.

5.5 Ventilation.

5.5.1* Continuous forced ventilation using fresh air at the rate of at least 0.01 $m^3/sec/m^2$ (2 $ft^3/min/ft^2$) of floor area shall be provided in all support rooms handling flammable or combustible liquids.

5.5.2 Ventilation systems shall be arranged to draw heavier-than-air vapors or gases from near the floor level and discharge them to a safe location.

5.5.2.1 Where lighter-than-air gases are used, similar ventilation shall be provided but arranged to exhaust from ceiling level and with calculations based on the ceiling area.

5.5.2.2 Ventilation for lighter-than-air gases shall be designed to prevent pocketing of such gases at ceiling level.

5.5.2.3 Rotating elements of fans shall be of nonferrous or nonsparking materials, or the casing shall consist of, or be lined with, such material.

5.5.3 Where ventilation is provided, each cell or room handling flammable or combustible liquids or flammable gases shall have its own ventilation system to avoid interconnecting multiple hazards.

5.6 Fuel Systems and Lubricating Oil Systems.

5.6.1 Fuel systems and lubricating oil systems shall meet the requirements of NFPA 30.

5.6.1.1 Plastic, aluminum, or cast-iron pipe, valve bodies, and fittings shall not be permitted to be used above ground in test facilities.

5.6.2* Fuel systems shall be equipped with manually operated control valves located at strategic points both outside and inside the engine test facility so that the main fuel supplies can be shut down quickly in the event of an emergency.

5.6.3* An emergency safety shutoff valve(s) shall be installed in the fuel supply line(s) to each test cell.

5.6.3.1 The valves shall be located outside each test cell.

5.6.3.2 The valve(s) shall close on operation of a readily accessible and placarded emergency control device.

5.6.4 Fuel lines from main fuel headers shall enter fuel handling areas and run to test cells without passing through the control room.

5.6.4.1 One of the following shall be installed in the piping system to protect the piping and equipment against overpressure due to thermal expansion of liquid in valved-off sections:

(1) Relief valves arranged to discharge into collection tanks

(2) Fuel return lines

(3) Other devices

5.6.5 Glass fuel flow measuring devices shall not be used.

5.6.6 Flexible sections in the fuel and lubricating oil systems shall be suitable for the fluid and for the temperature and pressure expected.

5.6.7 Fuel and lubricant piping within the test cell shall be located so as to minimize exposure to physical damage.

5.7 Compressed Air.

5.7.1 Compressed air piping systems shall conform to the requirements of ASME B31.1.

5.7.2 Materials in compressed air piping systems shall meet the following criteria:

(1) Materials shall be rated for the conditions of pressure and temperature expected.

(2) Materials shall be resistant to the fuels, oils, or hydraulic fluids to which they could be exposed.

5.7.3 Hose bands and joint couplings shall be of an approved type and shall be safety wired.

5.8 Hydraulic Fluids.

5.8.1* Hydraulic systems shall be designed in accordance with ASME B31.1.

5.8.1.1 Piping and fittings shall be designed to withstand maximum surge pressures in the system.

5.8.1.2 Piping shall be securely mounted to prevent failure due to vibration or mechanical damage.

5.8.1.3 Gasket materials and seals shall be suitable for the fluid used.

5.8.2* Properly identified, manually actuated devices that shut off the hydraulic pump drive system shall be provided in a readily accessible location so that pumps are shut off in the event of leakage, pipe or hose failure, or fire.

5.9* Instrumentation.

5.9.1 Computer rooms and electronic data processing equipment shall meet the requirements of NFPA 75 and the protection requirements specified in Chapter 4 of this standard.

5.9.2* Signal and control wiring or tubing shall be installed to minimize exposure from fuel hazards or physical damage resulting from engine disintegration.

5.9.3 Flowmeters or sensing lines containing fuel or oil shall not be located in the control room.

Chapter 6 Fire Protection Requirements

6.1 Engine Test Facility.

6.1.1 Portable fire extinguishers shall comply with the following:

(1) The extinguishers shall be provided throughout the engine test facility.

(2) The extinguishers shall meet the requirements of, and be distributed in accordance with, NFPA 10.

6.1.2 Portable fire extinguishers shall not be located within the engine test cell.

6.1.3 Class B hazards shall be classified as an Extra Hazard in accordance with NFPA 10.

6.1.4 Class A hazards shall be classified as at least an Ordinary Hazard in accordance with NFPA 10.

6.1.5 Hand Hose Lines.

6.1.5.1 As an alternative to the requirements of 6.1.1, hand hose lines using one or more of the following extinguishing agents shall be permitted in place of 50 percent of the required portable fire extinguishers:

(1) Water, meeting the requirements of NFPA 14

(2) Carbon dioxide, meeting the requirements of Chapter 4 of NFPA 12

(3) Foam, meeting the requirements of NFPA 11

(4) Dry chemical, meeting the requirements of Chapter 6 of NFPA 17

6.1.5.2 Where hand hose lines are provided, each hose line station shall be located so it is easily accessible.

6.1.6 The engine test facility shall be provided with an alarm and communications system meeting the following criteria:

(1) The system shall meet the requirements of Section 9.6 and 40.3.4 of NFPA *101*.

(2) The system shall notify personnel in the control room and engine test cell.

6.1.7* Where provided, fire detection systems shall meet the requirements of *NFPA 72*.

6.2* Engine Test Cell.

6.2.1* At least one of the following fire protection systems shall be provided to protect each engine test cell:

(1) Carbon dioxide system meeting the requirements of Sections 7.1 and 7.2

(2) Halon system meeting the requirements of Sections 7.1 and 7.3

(3) Foam system meeting the requirements of Sections 7.1 and 7.5

(4) Water spray system meeting the requirements of Sections 7.1 and 7.6

(5) Water deluge system meeting the requirements of Sections 7.1 and 7.6

(6) Automatic sprinkler system meeting the requirements of Sections 7.1 and 7.6

6.2.1.1 The systems specified in 6.2.1 shall have a manual release located within the control room.

6.2.1.2 The systems specified in 6.2.1 shall not be required to be automatically actuated.

6.2.2 Where provided, automatic actuation shall be permitted to be bypassed during engine operation, provided that the following criteria are met:

(1) The control room is continuously attended.

(2) Detection devices and alarms remain in service at all times.

(3) Any permitted bypass function is electrically supervised.

6.2.3 A separate fire protection system control valve shall be provided for each engine test cell.

6.2.4 Extinguishing systems for engine test cells shall be designed to compensate for the high airflows encountered during operation and engine rundown time.

6.2.5 Where provided, time delay for system discharge shall be not less than that required for egress of personnel but shall be permitted to be extended to compensate for engine rundown time.

6.2.6 Piping, nozzles, and actuation systems shall be located to minimize the extent of physical damage in the event of engine disintegration.

6.3 Control Rooms.

6.3.1 Control rooms constructed of materials that are other than noncombustible or limited combustible as defined in NFPA 220 shall be protected by an automatic sprinkler system meeting the requirements of Sections 7.1 and 7.6 of this standard.

6.3.2* Control rooms constructed of either noncombustible or limited combustible materials as defined in NFPA 220 shall be provided with at least one of the following automatic fire protection systems:

(1) Halon 1301 total flooding system meeting the requirements of Sections 7.1 and 7.3

(2) Automatic sprinkler system meeting the requirements of Sections 7.1 and 7.6

6.4* Support Rooms.

All support rooms shall be provided with at least one of the following automatic fire protection systems:

(1) Carbon dioxide system meeting the requirements of Sections 7.1 and 7.2

(2) Halon 1301 system meeting the requirements of Sections 7.1 and 7.3

(3) Dry chemical system meeting the requirements of Sections 7.1 and 7.4

(4) Foam system meeting the requirements of Sections 7.1 and 7.5

(5) Water spray system meeting the requirements of Sections 7.1 and 7.6

(6) Water deluge system meeting the requirements of Sections 7.1 and 7.6

(7) Automatic sprinkler system meeting the requirements of Sections 7.1 and 7.6

Chapter 7 Fixed Fire Protection Systems

7.1 General Design Requirements.

7.1.1 Fire protection system control equipment shall be located outside of the hazard area.

7.1.2 All fire protection system control equipment shall be identified as to the hazard protected, the function performed, and the method of operation for manual controls.

7.1.3 Manual fire protection system controls shall be conveniently located and accessible at all times, including the time of fire.

7.2 Carbon Dioxide Systems.

7.2.1 Carbon dioxide systems shall meet the requirements of NFPA 12.

7.2.2 A carbon dioxide system shall have a connected reserve supply that is not less than 100 percent of the primary supply arranged for immediate manual discharge.

7.2.3 The actuation of the carbon dioxide system shall cause both of the following:

(1) Closing of the fuel valves supplying fuel to the protected area

(2) Activation of the alarm devices to warn personnel to evacuate the protected area

7.2.4 The actuation of a total flooding system shall cause the following in addition to the requirements of 7.2.3:

(1) Provision of time to allow personnel to egress before the extinguishing agent is discharged

(2) Shutdown of ventilating fans and closing of doors and other openings to minimize leakage of the extinguishing agent from the protected area

7.2.5 The closing of doors shall not prevent the egress of personnel from the protected area.

7.3 Halon Systems.

7.3.1* Halon systems shall meet the requirements of NFPA 12A.

7.3.2 Halon systems shall have a connected reserve supply not less than 100 percent of the primary supply arranged for immediate manual discharge.

7.3.3 The actuation of the system shall cause both of the following:

(1) Closing of the fuel valves supplying fuel to the protected area

(2) Activation of the alarm devices to warn personnel to evacuate the protected area

7.3.4 The actuation of a total flooding system shall cause the following in addition to the requirements of 7.3.3:

(1) Provision of time to allow personnel to egress before the extinguishing agent is

discharged

(2) Shutdown of ventilating fans and closing of doors and other openings to minimize leakage of the extinguishing agent from the protected area

7.3.5 The closing of doors shall not prevent the egress of personnel from the protected area.

7.4 Dry Chemical Systems.

7.4.1 Dry chemical systems shall meet the requirements of NFPA 17.

7.4.2 The actuation of the system shall cause all of the following:

(1) Closing of the fuel valves supplying fuel to the protected area

(2) Activation of the alarm devices to warn personnel to evacuate the protected area

(3) Provision of sufficient time to allow personnel to egress before the extinguishing agent is discharged

(4) Shutdown of ventilating fans

7.5 Foam, High-Expansion Foam, Foam-Water Sprinkler, and Foam-Water Spray Systems.

7.5.1 Low-expansion foam extinguishing systems shall meet the requirements of NFPA 11.

7.5.2 High-expansion foam systems shall meet the requirements of NFPA 11A.

7.5.3 Foam-water sprinkler systems and foam-water spray systems shall meet the requirements of NFPA 16.

7.5.4 The actuation of a foam, high-expansion foam, foam-water sprinkler, or foam-water spray system shall cause all of the following:

(1) Closing of fuel valves supplying fuel to the protected area

(2) Activation of alarm devices to warn personnel to evacuate the protected area

(3) Provision of time to allow personnel to egress before the extinguishing agent is discharged

(4) Shutdown of ventilating fans and automatic closing of doors

7.5.5 In engine test cells only, the total discharge rate shall be calculated based on the required density over the total floor area.

7.5.6 In engine test cells only, discharge devices shall be arranged to provide coverage of the hazard area.

7.5.6.1 Discharge devices located at the ceiling shall provide complete coverage over the floor area.

7.5.6.2 Directional discharge devices shall project the foam onto the thrust stand regardless of the discharge device location.

7.6 Water Spray Systems, Water Deluge Systems, and Automatic Sprinkler Systems.

7.6.1 Water spray systems shall meet the requirements of NFPA 15.

7.6.2 Water deluge systems and other automatic sprinkler systems shall meet the requirements of NFPA 13.

7.6.3* In engine test cells, the minimum design discharge density shall be 0.34 $L/sec/m^2$ (0.50 gpm/ft^2) of protected area.

7.6.4 In engine test cells, water supplies shall be capable of meeting the largest demand at the design rate plus hose stream demand for a period of 30 minutes.

7.6.4.1 Hose stream demand shall be a minimum of 16 L/sec (250 gpm).

7.6.4.2 The hydraulic calculation and the water supply shall be based on the assumption that all sprinklers in the test cell are operating simultaneously.

Chapter 8 Employee Organization for Fire Safety

8.1 General.

8.1.1 All personnel engaged in aircraft engine testing operations and all other persons regularly employed and working around engine test facilities shall be instructed in fire prevention practices as part of their regular training.

8.1.2 The regular training shall include the following:

(1) Operation of all portable fire extinguishers in the area in which personnel work

(2) Operation of all hose line systems in the area in which personnel work

8.1.3 Select personnel on each operational shift shall be trained as follows:

(1) Personnel shall be trained in the operation of the fixed fire protection systems provided in the test facility.

(2) The training shall be accompanied by a comprehensive explanation of all features of the systems and the area they protect.

8.1.4 Responsibility for fire protection equipment, inspection, and maintenance shall be assigned to key personnel.

Annex A Explanatory Material

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

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

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

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

A.4.1.4 Analysis should include, but not be limited to, the following:

(1) Type of testing to be done (e.g., production, endurance, development/research)

(2) Characteristics of the fuel (e.g., flash point, vapor density, autoignition temperature)

(3) Amount of airflow and whether it is ducted to the engine

(4) Presence of continuous ventilation

(5) Fuel quantity in relation to volume of the enclosure

(6) Maximum fuel pressure, temperature, flow, and delivery system

(7) Life safety considerations

Test cells can be subject to an explosion hazard because of the presence of flammable vapors and the confinement of them within the test cell. The potential damage from an explosion depends on numerous factors, including the following:

(1) Designed pressure resistance of the structure

(2) Amount of area utilized for inlet and exhaust air

(3) Amount of explosion venting provided

(4) Amount of continuous ventilation provided

(5) Presence of explosion suppression equipment

Explosion venting, continuous ventilation, and/or explosion suppression should be considered in the design of test cells. The planned use of the cell, the supporting equipment, the type of construction, and the configuration of the cell are some of the factors to be considered. *(See A.5.5.1.)* The net unobstructed area of engine test cell inlet and exhaust passages can be included in the venting area. Explosion venting could be effected in the cells proper by the use of lightweight roof or wall panels or outward opening doors equipped with resisting devices to prevent the venting device from being projected, with chance of injury to personnel or damage to equipment in the event of operation. Guidance for explosion venting is provided in NFPA 68. Where the specific design or configuration of a test facility does not allow the use of explosion venting, or allows very minimal explosion venting, consideration should be given to the protection of the structure or specialized equipment by the use of explosion suppression systems. Requirements for explosion suppression systems are provided in NFPA 69.

A.4.2 Test cell walls should not form common walls with main manufacturing buildings. Test cells should be located to minimize the exposure from openings such as doors, windows, inlet and exhaust stacks, ventilating ducts, explosion vents, or exhaust pipes to the following:

(1) Combustible construction or unprotected openings at the same or higher elevation

(2) Utilities such as transformers, overhead transmission lines, overhead service piping, and cooling towers

Where test cells are of light construction, important exposed buildings and utilities should be shielded from the possible disintegration of aircraft engines.

Other walls, ceilings, and floor assemblies comprising the engine test facility should be of fire-resistive, protected noncombustible, or noncombustible construction. The type of construction utilized in test buildings is determined to an extent by a building's proximity to main buildings or vital utilities.

A.5.1.1 Parts or foreign objects (e.g., tools, lockwire, nuts, bolts, washers, stones) in front of a turbine engine or in other locations where they might be ingested into an engine are likely to cause damage to the engine or to a critical system and cause a fire. Test cell operating procedures should therefore include a thorough inspection of the test cell and engine before engine starting to check for safety of parts and to eliminate foreign objects.

A.5.2.1 Test cells and support rooms not containing flammable liquid– or combustible liquid–handling systems could also require drainage systems to effectively dispose of water used for engine washing, exhaust gas cooling system malfunctions, rainwater, and water discharged from fire protection systems. Test cell floor drains should be located, where possible, downwind of probable fuel spill locations to minimize the pounding effect of high test cell air velocity. Requirements of federal, state, and local environmental agencies should be consulted.

A.5.2.4 Where deluge sprinkler systems are installed, the capacity of the drainage system can be determined by increasing the sprinkler design rate by an appropriate correction for maximum main pressure. Exhaust gas cooling water rates do not need to be included in the determination of peak drainage if an adequate emergency shutoff system or separate drainage system is provided.

A.5.2.5 All drain traps should be provided with an automatic reseal system.

A.5.3.3 It is common practice to locate limit switches for elevating work platforms below the floor level. An accidental shorting or grounding of these circuits should not allow the elevator to move or overrun, which could result in damage to engine fuel lines and in ensuing fire.

A.5.3.8 The failure of electric power supply to a test cell might deprive the operator of control of the engine, resulting in possible engine damage and ensuing fire. Battery power or other means should be provided to properly operate the engine during such failures.

A.5.4.1 Heating and cooling systems used in conjunction with engine test facilities require careful design and installation because of the magnitude of the hazards, the complexity of the operations, and the operational importance of the facility.

A.5.4.2 Surface temperatures of exposed heating elements should not equal or exceed the minimum autoignition temperature of the most hazardous flammable liquid or gas used.

A.5.4.3 Direct cooling systems should be used, rather than systems that utilize extensive ductwork that penetrates cell walls.

A.5.4.4 Test cell inlet preheaters used to simulate hot inlet air conditions should use steam or a liquid heat exchange medium. Auxiliary fans to allow pre- and post-operation purging prior to lightoff and after running might be needed. Four complete cell air changes should be made before purging is considered complete. Preheaters utilizing gaseous fuel should have continuous gas detectors sampling all areas subject to flammable vapor accumulation. Gas detection systems should be interlocked to shut off gas and sound an alarm at 25 percent of the lower flammable limit.

A.5.5.1 Forced air ventilation at the rate of 0.005 $m^3/sec/m^2$ (1 $ft^3/min/ft^2$) of floor area should be provided in engine test areas when engines are not running.

A.5.6.2 An additional fuel shutoff valve should be located before any flexible connection to the engine to isolate fuel inside the test cell if the quantity contained between the test cell wall and the engine is significant.

A.5.6.3 Consideration should be given to the automatic operation of the emergency fuel safety shutoff valve by one or more of the following methods:

(1) Operation of the fire protection system

(2) Actuation of heat sensing devices

(3) Excess fuel flow

A.5.8.1 Many hydraulic systems utilize combustible oil under high pressure to transmit power or motion. The use of combustible hydraulic oils presents a potential fire and explosion hazard. Atomization of such fluids greatly increases the ease of ignition.

Use of hydraulic fluids with low fire hazard potential is encouraged. Such fluids include water-glycol, halogenated-hydrocarbon, phosphate-ester, and water-oil emulsion types. When converting from one hydraulic fluid to another, the entire hydraulic system should be thoroughly cleaned, and seals, packings, valves, or pumps should be changed to prevent leakage. Equipment and fluid manufacturers should be consulted for proper conversion procedures in these non-engine-related hydraulic systems.

The use of flexible connectors and hoses should be avoided.

A.5.8.2 The hydraulic line should also be shut off by these devices to minimize fluid leakage.

A.5.9 Instrumentation is an essential part of every engine testing facility and can include flowmeters, pressure and temperature sensors, indicators, gauges, transducers, thrust and position indicators, vibration monitors, and so forth.

A.5.9.2 Control instrumentation should be arranged so that its failure will not introduce a hazard. Where combustible pneumatic tubing is grouped in cable trays or troughs, additional fire protection might be needed to prevent extensive damage to the tubing system.

A.6.1.7 When a fire detection system is installed to sound an alarm or actuate a fire extinguishing system, the detection system design should consider airflows, engine location, heat sources from the engine, and whether the engine is being continuously observed. In test facilities where airflow velocities in excess of 7.6 m/sec (25 ft/sec) are expected, optical detection should be used.

A.6.2 See Annex B.

A.6.2.1 See Annex C.

A.6.3.2 See Annex C.

A.6.4 See Annex C.

A.7.3.1 Halon 1211 and Halon 1301 are included in the "Montreal Protocol on Substances that Deplete the Ozone Layer," signed September 16, 1987. The 1992 amendments to the protocol call for a worldwide cessation of production of Halon 1211 and Halon 1301.

A.7.6.3 Because of the nature of the test cell fire potential, deluge systems are considered more appropriate than automatic sprinklers due to their speed of operation and simultaneous discharge of all nozzles; however, automatic sprinklers can be used as follows:

(1) In small cells [56 m^2 (600 ft^2) or less] where it is likely that all sprinklers would fuse at the same time

(2) As a backup to a manual water spray or other manual system

Annex B Supplementary Fire Protection Systems

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

B.1 General.

Where supplementary fire protection systems are provided for engine protection in addition to the required engine test cell fire protection, they should be designed and installed in an approved manner. The more common supplementary systems used for engine protection are outlined in B.1.1 and B.1.2.

B.1.1 Carbon Dioxide Spurt System. A carbon dioxide spurt system is usually a manually actuated fixed-pipe system designed to locally apply carbon dioxide to an engine on an intermittent basis or continuously. A spurt system can have its own agent supply or can be supplied from a total flooding or local application carbon dioxide system. Such a system is intended to provide a means for quick knockdown of fires in or around the engine while the engine is operating. There are usually no interlocks to shut down fuel flows, alarms, and so forth.

B.1.1.1 Pipings and fittings should conform to the applicable provisions of NFPA 12.

B.1.1.2 The primary supply and connected reserve supply should each be designed to provide a continuous discharge for a minimum of 3 minutes.

B.1.2 Steam Fire Protection Systems. Steam extinguishes a fire in a manner similar to inert gases. To maintain steam in its true form at normal atmospheric temperatures and pressures and prevent it from condensing to water vapor, very large quantities should be discharged at one time.

B.1.2.1 The need to discharge steam in such large quantities makes its use impractical for total flooding of a large test cell. It can be effective for engine fires when discharged within an enclosing cowl, when injected into cavities within the engine, or when injected into the main inlet air stream or the tailpipe of an engine.

B.1.2.2 Such factors as boiler maintenance, standby boilers, boiler fuel availability, normal peak steam demand, boiler feedwater availability, and availability of alternative emergency fire protection services should be considered in analyzing steam source requirements or suitability. Guidelines are offered in B.1.2.2.1 through B.1.2.2.7.

B.1.2.2.1 Steam can be used as an effective supplementary system for engine protection, provided that steam is available in sufficient quantities whenever the test cell is in operation.

B.1.2.2.2 Piping for the distribution of steam from the source to the point of use should follow ASME B31.1, as applicable.

B.1.2.2.3 The steam flow rate should be sufficient to achieve a ratio of steam volume to total protected volume of 50 percent within 30 seconds. The steam supply should be capable of maintaining the concentration until the fire has been extinguished. Steam discharge to atmosphere of not less than 15 psi (103 kPa) can be approximated by the following formula:

$$W = 0.7A(P+15)$$

where:

W = pounds of steam per minute

0.7 = constant including an orifice coefficient

A = orifice area (in.^{2})

P = gauge pressure at outlet (psi)

B.1.2.2.4 For more precise determination of required orifice size, or when upstream and downstream pressure conditions differ from those specified in B.1.2.2.3, a standard textbook on steam flow control should be consulted.

B.1.2.2.5 The system should not be automatically actuated. Personnel hazards should be considered prior to manual actuation.

B.1.2.2.6 Steam condensate traps and lines should be provided to bleed off liquid and allow only vapor to be directed to the protected area.

B.1.2.2.7 The steam system should be inspected and tested at least semiannually.

Annex C Agent Selection

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

C.1 General.

Each agent has its advantages and disadvantages, and the choice of agent or combination of agents should be made only after careful consideration of the objective of the protection and the conditions of each individual installation. Factors pertinent to each agent are outlined in C.1.1 through C.1.5.

C.1.1 Water.

C.1.1.1 Water, particularly in spray form, is an effective agent in controlling or extinguishing kerosene-grade (e.g., JET A or A-1; JP-5 or JP-8) jet fuel fires. Water is not an effective extinguishing agent for fuels containing gasoline (e.g., JET B; JP-4). The principal advantage of water is its superior cooling capacity. Other advantages are adequate supply for continuous discharge over long periods, ease of piping, and low cost.

C.1.1.2 The disadvantages of water include drainage requirements and possible water damage to the test engine, electrical devices, wiring, and instrumentation. Deluge systems are considered more appropriate than closed head automatic sprinklers due to their speed of operation and simultaneous discharge from all nozzles. Automatic sprinklers can be effectively used in small test cells [56 m^2 (600 ft^2) or less] where it is likely that all sprinklers would fuse at the same time or as a backup to a manual water spray or other manual system.

C.1.2 Carbon Dioxide.

C.1.2.1 Carbon dioxide is an effective extinguishing agent for flammable liquid fires when applied in sufficient concentration. Its principal advantage is lack of agent damage. Other advantages are that cleanup is not necessary and the cost for recharging the system is relatively low.

C.1.2.2 The disadvantages of carbon dioxide include the need to evacuate personnel from a protected area, limited supply of agent, potential leakage of agent from a protected space, and lack of significant cooling effect.

C.1.3 Foam.

C.1.3.1 Foam is an effective extinguishing agent for all aviation fuels. It is most useful for fires involving large spills. Other advantages are its ability to cover large fuel spills before they become ignited and its insulating qualities.

C.1.3.2 The disadvantages of foam include lack of effectiveness on three-dimensional fires (e.g., fuel flowing from an elevated source), cost of agent, and need for cleanup. Foam systems are not effective on fires involving flammable gases.

C.1.4 Dry Chemical.

C.1.4.1 Dry chemical extinguishing agents are effective for flammable liquid and gaseous fires. They have rapid knockdown and extinguishing capability.

C.1.4.2 Dry chemical extinguishing agents are not considered desirable for test cell coverage due to extensive cleanup required and potential damage to electrical contacts and engine parts.

C.1.5 Halon.

C.1.5.1 Halon can be used for extinguishing fuel spill fires and engine fires. It has the ability to extinguish or suppress fires in surface-burning Class A materials and extinguish Class B fires and is safe to use on Class C (electrical) fires. The compatibility of the agents with engine parts should be investigated, because the decomposition products could be corrosive.

C.1.5.2 The only halons recommended for test facility protection are Halon 1301 and Halon 1211. Both agents require lower extinguishing concentrations than carbon dioxide, resulting in smaller piping and less agent storage. See NFPA 12A for more descriptive information.

Annex D Informational References

D.1 Referenced Publications.

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

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

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2000 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2004 edition.

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

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

D.1.2 Other Publications.

D.1.2.1 ASME Publication. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B31.1, *Code for Power Piping*, 1998 edition.

D.2 Informational References. (Reserved)

D.3 References for Extracts.

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

NFPA 409, *Standard on Aircraft Hangars*, 2004 edition.

Formal Interpretation

Formal Interpretation

NFPA 423

Construction and Protection of Aircraft Engine Test Facilities

2004 Edition

Reference: 7.6.3
F.I. 89-1 (NFPA 423)

Question 1: For automatic sprinkler system protection for an engine test cell, is the "protected area" the entire floor area?

Answer: Yes.

Question 2: For water deluge system protection for an engine test cell, is the "protected area" the entire floor area?

Answer: Yes.

Issue Edition: 1989
Reference: 5-6.3
Issue Date: April 18, 1994
Effective Date: May 8, 1994

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