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Standard for

Construction and Protection of Aircraft Engine Test Facilities

NFPA 423 — 1977

1977 Edition of NFPA 423

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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. This 1977 edition contains the results of that coordination effort.

Aviation Correlating Committee

James J. Brenneman, *Chairman*
Fire Protection Engineer
United Airlines, San Francisco International Airport
San Francisco, CA. 94128

James J. Brenneman, *Chairman,*
Sectional Committee on Aircraft Rescue and Fire Fighting

Oscar W. Bush, *Vice-Chairman,*
Sectional Committee on Aircraft Fuel Servicing

F. P. DeGiovanni, *Vice-Chairman,*
Sectional Committee on Airport Facilities

B. V. Hewes, *Vice-Chairman,*
Sectional Committee on Aircraft Rescue and Fire Fighting

J. A. O'Donnell, *Chairman,*
Sectional Committee on Aircraft Fuel Servicing

Calvin E. Smith, *Chairman,*
Sectional Committee on Airport Facilities

Kenneth A. Zuber, *Chairman,*
Sectional Committee on Aircraft Maintenance Operations

Sectional Committee on Airport Facilities

Calvin E. Smith, *Chairman*
Director, Facilities Engineering and Development
Metropolitan Air Facilities Division, Pan American World Airways
Teterboro Airport, Teterboro, N.J. 07608

F. P. DeGiovanni, *Vice-Chairman*
Project Manager, Facilities
American Airlines, 633 Third Avenue, New York, N.Y. 10017

Arthur E. Cote, *Acting Secretary* (Nonvoting)
National Fire Protection Assn., 470 Atlantic Ave., Boston, MA. 02210

H. T. Anderson, Asst. for Fire Protection Engineering, U. S. Department of the Navy, Naval Facilities Engineering Command

Donald S. Armstrong, Air Canada, Air Canada Base, Montreal International Airport

Charles F. Averill, Grinnell Fire Protection Systems Co., Inc. (rep. National Automatic Sprinkler & Fire Control Association)

Gene E. Benzenberg, Alison Controls Inc.

James J. Brenneman, Fire Protection Engineer, United Airlines

R. G. Canning, Office of the Canadian Forces Fire Marshal, Canadian Forces Headquarters, National Defence Headquarters

J. Walter Coon, Burns & McDonnell

J. M. Dewey, Kemper Insurance Cos., HPR Department (rep. American Mutual Insurance Alliance)

Donald A. Diehl, Senior Fire Protection Engineer, Pyrotronics, Inc. (rep. National Electrical Manufacturers Association)

Herbert W. Eisenberg, Eisenberg, Haven, Smith Associates, Inc. (rep. American Institute of Architects)

Stanley D. Granberg, Corporate Chief of Fire Protection Engineering, The Boeing Company

Stuart C. Hand, J. S. Frelinghuysen Corporation

D. C. Hanson, Director Process Engineering, Trans World Airlines, Inc., Kansas City International Airport

E. B. Hoge, Facilities Engineering, Eastern Airlines, Miami International Airport

R. L. Jackson, Exxon Company, USA. (rep. American Petroleum Institute)

L. M. Krasner, Factory Mutual Engineering Corporation

Thomas J. Lett, U.S. Department of the Air Force, Hq. Air Force Contract Management Division (AFSC), Kirtland AFB

Fred Linde, National Foam System, Inc.

J. W. MacDonald, British Airways

A. J. Mercurio, Industrial Risk Insurers (Hartford)

Eugene Schafran, The Port Authority of New York & New Jersey (rep. Airport Operators Council International)

Eugene Stauffer, The Ansul Co. (rep. Fire Equipment Manufacturers Association, Inc.)

Alternates

K. J. Brewer, Office of the Canadian Forces Fire Marshal, Canadian Forces Headquarters (Alternate to R. G. Canning)

James D. Dick, Kemper Insurance Cos., HPR Department (Alternate to J. M. Dewey)

Roger B. Jones, Walter Kidde & Co., Inc. (Alternate to D. A. Diehl)

Donald Maddock, The Ansul Company (Alternate to Eugene Stauffer)

Joseph H. Priest, Grinnell Fire Protection Systems Co., Inc. (Alternate to Charles F. Averill)

V. G. Pyrpyris, The Port Authority of New York & New Jersey (Alternate to Eugene Schafran)

William F. Schacht, Industrial Risk Insurers (Chicago) (Alternate to A. J. Mercurio)

Richard Southers, American Petroleum Institute (Alternate to R. L. Jackson)

Nonvoting

James Hammack, Consultant, San Pedro, CA

Jerome Lederer, President Emeritus, Flight Safety Foundation, Laguna Hills, CA

Subcommittee on Aircraft Engine Test Facilities

To carry on the work on this standard the following Sub-committee has been in charge of the activities leading up to this 1977 Edition.

Harry T. Anderson, *Chairman,* Naval Facilities Engineering Command

Donald A. Diehl, *Secretary,* Pyrotronics, Inc. (rep. National Electrical Manufacturers Association)

Charles Averill, Grinnell Fire Protection Systems Co. (rep. National Automatic Sprinkler and Fire Control Association)

Frank L. Gallant, General Electric Company, Aircraft Engine Group

Oliver J. Parsons, Eastern Air Lines

Henry J. Perrault, Pratt & Whitney, Aircraft Division

Dexter B. Tucker, Industrial Risk Insurers (Hartford)

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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NOTICE

An asterisk(*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Appendix B.

Standard for Construction and Protection of
Aircraft Engine Test Facilities
NFPA 423 — 1977

Chapter 1 General

1-1 Scope. This standard deals with fire safety practices regarding location, construction, services, utilities, fire protection, operation, and maintenance of new aircraft engine test facilities and modifications made to existing test facilities which could affect the fire and explosion hazard potential within such facilities. These facilities include test cells, test stands, and engine run-up enclosures. This standard applies to test facilities designed to operate only at ground level conditions of temperature and pressure. This standard does not apply to engines and engine accessories, nor to engine test facilities where other than hydrocarbon fuels are used.

1-2 Definitions and Units.

1-2.1 Engine Run-up Enclosure. An integrated system consisting of a complete enclosure or engine air intake and engine exhaust gas ducts with, if necessary, silencers, exhaust gas turning equipment, and exhaust gas cooling equipment, for use with aircraft during ground testing of aircraft mounted engine(s). The system may be stationary, semiportable, or portable.

1-2.2 Engine Test Cell. The space in which the test engine is installed during a test. This space is totally enclosed by permanent building components except where the enclosure is breached by air ducts, exhaust ducts, services, access ports and/or doors.

1-2.3 Engine Test Facility. An integrated system of building(s), structure(s), space and services, used to test aircraft engines.

1-2.4 Control Room. A room with instrumentation and devices to control, measure and/or record test cell and engine operations and performance.

1-2.5 Support Room. An enclosure, excluding the test cell or control room, which is an integral part of the engine test facility. Included are fuel cubicles, fuel handling rooms, hydraulic rooms, preparation areas, etc.

1-2.6 Test Stand. An integrated system for testing an aircraft engine, as in a test cell, except that the engine test space is not totally enclosed within a permanent building.

1-2.7 Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (litre and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-2.7 with conversion factors.

1-2.7.1 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. A given equivalent value may be approximate.

1-2.7.2 The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

Table 1-2.7

Name of Unit	Unit Symbol	Conversion Factor
litre	l	1 gal. = 3.785l
litre per minute per square metre	$l/\text{min.m}^2$	1 gpm/ft^2 = 40.746$l/\text{min.m}^2$
cubic decimetre	dm^3	1 gal. = 3.785 dm^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10^5 Pa

For additional conversions and information see ASTM E380-76, *Standard for Metric Practice.*

Chapter 2 Location, Construction and Internal Subdivisions

2-1* Location of Aircraft Engine Test Facilities. The degree of hazard varies depending upon the purpose of the test facility (e.g., production testing, development/research testing, or maintenance testing). Design considerations include the uniqueness of the particular test facility; the importance of the facility; and the exposure to existing or planned development, manufacturing or maintenance operations. The exposure hazard from test facilities to other structures or utilities can be reduced by providing open space between them. Where such space is available, tests may be conducted out-of-doors or in light, noncombustible structures. However, such additional factors as the necessity of conducting repeated tests, tests on many units at once, sound control, control of ambient temperature and other test conditions, and materials-handling requirements usually result in the building of substantial engine test cells and associated facilities adjacent to or within main plant areas.

2-2 Construction of Aircraft Engine Test Facilities.

2-2.1* Test cell walls, ceilings and floor assemblies shall be of the fire-resistive or protected-noncombustible construction as defined in the *Standard Types of Building Construction,* NFPA 220.

2-2.2 Materials of construction such as thermal or acoustic insulation used within the test cell shall be noncombustible as defined in NFPA 220.

2-2.3 New engine test facilities shall be constructed without basements or below grade areas except those recesses in the floor necessary to accommodate sump pumps, drainage facilities, or lifting platforms.

2-2.4 In existing facilities all basement areas, tunnels or other below grade spaces shall be eliminated, or the fuel handling system shall be segregated, drainage shall be provided, and the basement area 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.

2-2.5* Test cells may be subject to an explosion hazard because of the accidental presence of flammable vapors and the confinement of same within the test cell. Explosion-prevention, explosion-venting, or explosion-suppression measures (or a combination of same) shall be considered.

2-3 Internal Subdivisions of Aircraft Engine Test Facilities.

2-3.1 In designing subdivisions of engine testing facilities, the basic considerations are:

(a) Protection of personnel.
(b) Isolation of the engine under test.
(c) Isolation of the fuel handling equipment.
(d) Protection of test or control equipment.

2-3.2 These objectives may be accomplished by substantial internal cutoffs for:

(a) Test cells where an engine disintegration or other severe incident may occur;

(b) Areas for fuel handling systems and associated equipment, and

(c) Control rooms for protection of personnel and control instrumentation.

Chapter 3 Services and Utilities

3-1 General Safeguards.

3-1.1* All supports, nuts, bolts, etc. located where they may be ingested into an aircraft turbine engine shall be positively secured by safety wires, by tack welding, by suitable adhesive, or by approved aircraft-type locking devices; or an inlet screen of proper design shall be used to protect an engine from foreign object damage.

3-1.2 All materials likely to become exposed to fuels, oils, or hydraulic fluids shall be resistant to the fluid used.

3-2 Drainage.

3-2.1* **General.** Drainage systems shall be provided for engine test cells and support rooms containing flammable or combustible liquid handling systems to reduce the fire and explosion hazards.

3-2.2 Design of Drainage Systems.

3-2.2.1 **Pitch of Floors.** Floors subject to possible spillage of flammable or combustible liquids shall be pitched a minimum of one percent (one foot per 100 feet) toward the drain(s). Drain(s) shall be located to minimize fuel spread and exposure to equipment.

3-2.2.2 **Curbs, Ramps or Drain Trenches.** Such curbs, ramps, or trenches shall be installed to prevent the flow of flammable or combustible liquids into adjacent rooms or buildings.

3-2.2.3* **Capacity.** Drainage systems shall be designed and installed to provide sufficient capacity to prevent buildup of flammable or combustible liquids and water (ponding effect) over the drain inlet under maximum possible water discharge rate.

3-2.2.4* **Drain Traps.** Drain traps shall have a trap seal water head. In test cells, the seal water head shall be greater than the expected difference between the test cell operating pressure and atmospheric pressure.

3-2.2.5 **Materials.** Drain piping and joints shall be resistant to deterioration by fuels, engine oil and aircraft hydraulic system fluids.

3-2.2.6 Oil Separators. Common or separate oil separator(s) shall be provided in drains from the engine area, the exhaust plenum area and support rooms. 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. Separator systems shall discharge flammable or combustible liquid product to a safely located tank, cistern, or sump.

3-2.3 Drain and Separator Maintenance. Maintenance checks and flushing shall be conducted on all drains and oil separators at least annually to assure that they are clear of obstructions.

3-3 Electrical.

3-3.1 Classification of Locations.

3-3.1.1 Any pit or depression below the level of the test cell floor shall be classified as a Class 1, Division 1 hazardous location as defined in Article 500 of the *National Electrical Code,* NFPA 70 [ANSI]. This classification shall extend up to floor level.

3-3.1.2 The entire area of the test cell (engine area, intake plenum, and exhaust plenum), including any adjacent and communicating areas not suitably cut off from the test cell, shall be classified as a Class 1, Division 2 hazardous location up to a level 18 inches above the floor.

3-3.1.3 Contiguous areas in which flammable liquids or vapors are not likely to be released, such as control rooms, preparation areas, hydraulic package rooms and other similar locations, shall not be classed as hazardous when adequately ventilated or when effectively cut off from the test cell by walls or partitions.

3-3.2* Wiring and Equipment in Hazardous Locations. All wiring and equipment which is or may be installed or operated within any of the hazardous locations defined in Section 3-3.1 shall conform to applicable provisions of Article 501 of the *National Electrical Code,* NFPA 70 [ANSI]. All wiring installed under the test cell floor shall conform to the requirements for Class 1, Division 1. When wiring is located in vaults, pits or ducts below the test cell floor, adequate drainage shall be provided.

3-3.3 Wiring Not Within Hazardous Locations.

3-3.3.1 All wiring in the exhaust plenum but not within a hazardous area shall be installed in rigid conduit.

3-3.3.2 Test facility wiring not associated with the engine and engine testing and not within a hazardous area shall be installed in accordance with Section 513-4(a) of the *National Electrical Code,* NFPA 70 [ANSI].

3-3.4 **Support of Wiring.** All wiring not enclosed in raceways (such as harness wires connecting to the engine, etc.) shall be adequately supported, laced or banded to minimize wear from air velocity and vibration.

3-3.5* **Special Controls.** A means shall be provided at the control console to shut off all electric power except emergency circuits to the test cell in the event that the engine disintegrates or fuel leaks develop during operation.

3-4 Heating and Cooling.

3-4.1* **General.** 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. Heating and cooling systems shall be arranged to:

(a) Reduce exposure of their vital elements from fire, explosion, and damage by flying metal;

(b) Eliminate introduction of ignition sources by components of heating systems;

(c) Minimize passage of fire through ductwork; and

(d) Eliminate pockets in which flammable vapors can accumulate.

3-4.2 **Types of Heating Systems.** Only 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. 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 ten (10) feet above the floor. A conveniently located remote control station shall be provided to shut down the warm air heating system.

3-4.3* **Cooling Systems.** Cooling systems utilizing flammable refrigerants shall not be installed nor used within the test cell.

3-4.4* Preheaters. When direct-fired inlet air preheaters are essential to simulate hot inlet air conditions, fuel safety controls as specified in the *Standard for Ovens and Furnaces,* NFPA 86A [ANSI] shall be provided. 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.

3-4.5 Direct-Fired or Indirect-Fired Heaters for Heating Test Cell Inlet Air. These heaters shall be designed in accordance with applicable sections of the *Standard for Oil Burning Equipment,* NFPA 31 [ANSI], the *National Fuel Gas Code,* NFPA 54 [ANSI], or the *Standard for the Storage and Handling of Liquefied Petroleum Gases,* NFPA 58 [ANSI]. Sections 3805 and 3812 of NFPA 31 [ANSI] are not applicable.

3-5 Ventilation.

3-5.1* Continuous forced ventilation using fresh air at the rate of two cubic feet per minute per square foot of floor area shall be provided in all support rooms handling flammable or combustible liquids.

3-5.2 Ventilation systems shall be arranged to draw heavier-than-air vapors or gases from near the floor level and discharge to a safe location. 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. Ventilation for lighter-than-air gases shall be designed to prevent pocketing of such gas at ceiling level. Rotating elements of fans shall be of nonferrous or nonsparking material, or the casing shall consist of or be lined with such material.

3-5.3 Where ventilation is provided, each cell or room handling flammable or combustible liquids or flammable gases shall have its own separate ventilating system in order to avoid interconnecting multiple hazards.

3-6 Fuel Systems and Lubricating Oil Systems.

3-6.1 Fuel systems and lubricating oil systems shall conform to the requirements of *Flammable and Combustible Liquids Code,* NFPA 30 [ANSI] except that plastic, aluminum or cast iron shall not be permitted to be used aboveground for pipe, valve bodies and fittings in test facilities.

3-6.2* Fuel systems shall be equipped with manually operated control valves located at strategic points both outside and inside the engine test building so that the main fuel supplies can be shut down quickly in the event of an emergency.

3-6.3* Emergency safety shutoff valve(s) shall be installed in the fuel supply lines to each test cell, located outside each test cell. This valve(s) shall be closed on operation of a readily accessible and placarded emergency control.

3-6.4 Fuel lines from main fuel headers shall enter fuel handling areas and run to test cells without passing through the control room. Relief valves arranged to discharge into collection tanks or fuel return lines or other suitable devices 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.

3-6.5 Glass fuel flow measuring devices shall not be used.

3-6.6 Flexible sections in the fuel and lubricating oil systems shall be suitable for the fluid and for the temperature and pressure to be expected.

3-6.7 Fuel and lubricant piping within the test cell shall be so located as to minimize exposure from physical damage.

3-7 Compressed Air.

3-7.1* Compressed air may be used for engine starting and is often used as a source of power. Hot compressed air presents a potential ignition source.

3-7.2 Compressed air piping systems shall conform to requirements of the *Code for Power Piping* [ANSI B31.1].

3-7.3 Materials in compressed air piping systems shall be rated for the conditions of pressure and temperature expected. They shall be resistant to the fuels, oils, or hydraulic fluids to which they may be exposed.

3-7.4 Hose bands and joint couplings shall be of a reliable type, properly safety wired.

3-8 Hydraulic Fluids.

3-8.1* Many hydraulic systems utilize combustible oils 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.

3-8.2 Manually actuated devices shall be provided in a readily accessible location (such as the control room console), properly identified, to shut off hydraulic pumps in event of leakage, pipe or hose failure, or fire. They shall shut off the hydraulic pump drive system, and, where feasible, shall shut off the hydraulic line to minimize hydraulic fluid leakage.

3-8.3* Systems shall be designed in conformance with the *Code for Power Piping* [ANSI B31.1]. Piping and fittings shall be designed to withstand maximum surge pressures in the system. Piping shall be securely mounted to prevent failure due to vibration or mechanical damage. Gasket materials, seals, etc. shall be suitable for the fluid used.

3-9 Instrumentation.

3-9.1 Instrumentation is an essential part of every engine testing facility. Instrumentation may include flowmeters, pressure and temperature sensors, indicators, gauges, transducers, thrust and position indicators, vibration monitors, etc.

3-9.2 Computer rooms and electronic data processing equipment shall be installed and protected in accordance with the *Standard for Electronic Computer/Data Processing Equipment,* NFPA 75 [ANSI].

3-9.3* Signal and control wiring or tubing shall be installed to minimize exposure from fuel hazards or physical damage from engine disintegration.

3-9.4 Flowmeters or sensing lines containing fuel or oil shall not be located in the control room.

Chapter 4 Fire Protection

4-1 Extinguishing Systems for Engine Test Facilities.

4-1.1* Extinguishing Agents — General. There are several extinguishing agents that are acceptable for use in fixed systems for the protection of engine test facilities. Included are water, carbon dioxide, foam, dry chemical, halogenated fire extinguishing agent systems, or combinations of such systems. Steam and spurt carbon dioxide systems may be used as supplementary systems for engine protection (*see Section 4-6*).

4-1.2 Fire Protection System Requirements. Fixed fire protection systems shall be provided throughout the engine test facility as specified in Subsections 4-1.2.1 through 4-1.2.4 of this chapter and shall be designed in accordance with the appropriate text in this chapter.

4-1.2.1 Engine Test Cell. One or more of the following fire protection systems shall be provided within each engine test cell.

(a) Carbon dioxide extinguishing system (total flooding or local application type).
(b) Halogenated fire extinguishing agent system.
(c) Foam or foam-water sprinkler system.
(d) Water spray system.
(e) Water deluge sprinkler system.
(f) Closed head automatic sprinkler system.

Systems (a) through (e) shall have a manual release located within the control room. Systems (a) through (e) shall be actuated automatically or by manual means alone.

4-1.2.2 Supplementary Systems for Engine Protection. Where provided, steam or carbon dioxide spurt systems designed for supplementary engine fire protection shall be installed in accordance with Section 4-6. Other engineered supplementary systems may be approved.

4-1.2.3 Control Rooms.

4-1.2.3.1 Halon 1301 Total Flooding Systems.

(a) Where there is a critical need to protect data in process, reduce equipment damage, and facilitate return to service, consideration shall be given to the use of Halon 1301 Total Flooding Systems in sprinklered or unsprinklered control rooms.

(b) In installations where Halon 1301 Total Flooding Systems are used, they shall be installed and maintained in accordance with the requirements of *Standard on Halogenated Extinguishing Agent Systems — Halon 1301,* NFPA 12A [ANSI].

(c) Halon 1301 Systems shall be automatically actuated by an approved method of detection, meeting the requirements of *Standard on Automatic Fire Detectors,* NFPA 72E [ANSI]. To insure detection, particular attention shall be given to the choice of actuation means, the air flows usually involved in such air handling systems, and the small heat release under fire conditions.

(d) Where operation of the air conditioning system would exhaust the agent supply, the Halon 1301 System shall be interlocked to shut down the air conditioning when the Halon system is actuated.

(e) Halon 1301 Extinguishing Systems shall be arranged to automatically sound an alarm when actuated.

4-1.2.3.2 Automatic Sprinkler Systems.

(a) An automatic sprinkler system shall be provided to protect the control room when:

1. The control room construction contains any combustible materials.

2. The enclosure of a unit in a control room or the unit structure is built all or in part of a significant quantity of combustible materials, or

3. The operation of control room involves a significant quantity of combustible materials.

(b) Automatic sprinkler systems protecting control rooms shall be installed in accordance with *Standard for Installation of Sprinkler Systems,* NFPA 13 [ANSI].

4-1.2.4 Support Rooms.

(a) Support rooms which contain flammable or combustible liquids or flammable gases shall be provided with one of the following automatic fire protection systems:

1. Carbon dioxide extinguishing system.

2. Halogenated fire extinguishing agent system.

3. Foam or foam-water sprinkler system.

4. Water spray system.
5. Water deluge sprinkler system.
6. Closed head automatic sprinkler system.
7. Dry chemical extinguishing system.

(b) Support rooms containing significant quantities of Class A combustible materials shall be protected by an automatic sprinkler system installed in accordance with the *Standard for the Installation of Sprinkler Systems,* NFPA 13 [ANSI].

4-2 Extinguishing Systems for Engine Test Cells.

4-2.1 Carbon Dioxide Fixed Systems.

NOTE: See Section 4-6.1 for carbon dioxide spurt systems.

4-2.1.1 Total flooding or local application carbon dioxide systems shall be designed, installed, and tested in accordance with the *Standard for Carbon Dioxide Extinguishing Systems,* NFPA 12 [ANSI] and shall have a connected reserve supply not less than 100 percent of the primary supply arranged for immediate manual discharge.

4-2.1.2 The actuation of a total flooding system shall: (a) close fuel valves supplying fuel to the protected area; (b) activate alarm devices to warn personnel to evacuate the protected area; (c) provide sufficient time to allow personnel to egress before an injurious quantity of the extinguishing agent is discharged; and (d) cause ventilating fans to shut off and doors and other openings to close automatically to minimize the leakage of the extinguishing agent from the protected area. The automatic closing of doors shall not prevent the safe egress of personnel from the protected area. Where only manual actuation of carbon dioxide systems is planned, the closing of doors and other openings may be initiated manually. Systems which are arranged to actuate automatically shall also be provided with the means for manual operation.

4-2.2 Halogenated Fire Extinguishing Agent Systems.

4-2.2.1* For the purpose of this standard, the term halogenated fire extinguishing agent systems shall apply to systems discharging either Halon 1301 (bromotrifluoromethane) or

Halon 1211 (bromochlorodifluoromethane). Halon 1301 systems shall be designed, installed and tested in accordance with the *Standard for Halogenated Fire Extinguishing Agent Systems — Halon 1301,* NFPA 12A [ANSI]. Halon 1211 systems shall be designed, installed and tested in accordance with the *Standard for Halogenated Fire Extinguishing Agent Systems — Halon 1211,* NFPA 12B [ANSI].

4-2.2.2 Halogenated agent fire extinguishing systems shall have a connected reserve supply not less than 100 percent of the primary supply and arranged for immediate manual discharge.

4-2.2.3 Nozzles, piping, and detection systems shall be located in such a way or be otherwise protected to minimize physical damage in the event of an engine disintegration.

4-2.2.4 Halogenated fire extinguishing agent systems designed on a total flooding basis shall

(a) close fuel valves supplying fuel to the protected area;

(b) activate alarm devices to warn personnel to evacuate the protected area;

(c) provide sufficient time to allow personnel to egress before an injurious quantity of the extinguishing agent is discharged; and

(d) cause ventilating fans to shut off and doors and other openings to close automatically to minimize the leakage of the extinguishing agent from the protected area. The automatic closing of doors shall not prevent the safe egress of personnel from the protected area. Where only manual actuation is planned, the closing of doors and other openings may be initiated manually. Systems which are arranged to actuate automatically shall also be provided with the means for manual operation.

4-2.3 Foam, Foam-Water Sprinkler and Spray Systems.

4-2.3.1 For the purposes of this standard, the term "foam extinguishing system" shall mean a system discharging protein, fluoroprotein or aqueous-film-forming foam (AFFF) solutions from foam extinguishing systems, foam-water sprinkler systems or spray systems. High expansion foam systems, as described in the *Standard for High Expansion Foam Systems,* NFPA 11A [ANSI], are not included.

4-2.3.2 Foam extinguishing systems shall be designed, installed and tested in accordance with the *Standard on Foam Extinguishing Systems,* NFPA 11 [ANSI] or the *Standard on Synthetic Foam and Combined Agent Systems,* NFPA 11B [ANSI], as applicable.

4-2.3.3 Foam-water sprinkler and spray systems shall be designed, installed and tested in accordance with the *Standard on Foam-Water Sprinkler and Spray Systems,* NFPA 16 [ANSI].

4-2.3.4 Discharge devices shall be arranged to provide rapid coverage of the floor area. They may be located at the ceiling and spaced to provide complete coverage over the floor area, or at a low elevation along the walls. When located on the walls, the discharge outlets shall have a directional discharge so as to project the foam across the floor.

4-2.3.5* The rate of application of foam solution, duration of application, reserve supply of foam-producing materials, and water supply shall be in accordance with applicable provisions of the *Standard for Foam Extinguishing Systems,* the *Standard for Synthetic Foam and Combined Agent Systems,* or the *Standard for Foam-Water Sprinkler and Spray Systems.*

4-2.3.6* Foam system piping shall be Schedule 40 black steel with standard weight malleable iron or ductile iron fittings. Pipe sizing shall be determined by hydraulic calculation to achieve as even a distribution of foam discharge throughout the area as is practical.

4-2.3.7 Foam systems shall be capable of manual operation both at the control valve and from the control room.

4-2.4 Water-Spray Systems and Automatic Sprinkler Systems.

4-2.4.1 Water spray systems shall be designed, installed and tested in accordance with *Standard for Water Spray Fixed Systems for Fire Protection,* NFPA 15 [ANSI].

4-2.4.2 Sprinkler systems shall be designed, installed and tested in accordance with *Standard for the Installation of Sprinkler Systems,* NFPA 13 [ANSI]. Sprinklers serving each test cell shall have their own separate control valve of an approved indicating type. Valves shall be accessible or chain operated and clearly marked as to the area they control.

4-2.4.3* The minimum design discharge density for water spray, deluge and closed head automatic sprinkler systems in test cells shall be 0.50 gallons per minute, per square foot of protected area.

4-2.4.4 Water supplies for water spray, deluge and closed head automatic sprinklers shall be capable of supplying the largest system(s) within the test facility at the minimum design rate plus hose stream demand for a period of 30 minutes. Hose stream demand shall be a minimum of 250 gallons per minute. For closed head automatic sprinkler systems in test cells, the hydraulic calculation and the water supply shall be based on the assumption that all heads in the protected area are operating simultaneously.

4-2.4.5 In test cells protected by ceiling mounted sprinklers or water spray nozzles, additional directional water spray nozzles shall be provided as necessary to protect instrumentation cabletrays, large engines, and thrust stands.

4-2.4.6 Where water spray systems are designed for local application on the engine and thrust stands, nozzles shall be installed so that their water discharge completely envelops the equipment to be protected. Nozzle installations shall conform to their listed specifications.

4-2.4.7 Water spray and water deluge systems shall be manually operable both at the control valve and from the control room.

4-2.4.8 Piping, nozzles, and actuation systems shall be located to minimize the extent of physical damage in the event of engine disintegration. Deluge and control valves shall be located outside the test cell.

4-3 Alarms and Fire Detection Systems.

4-3.1 Detection and alarm systems in control rooms and where electronic computers are located shall be designed in accordance with the *Standard for Electronic Computer/Data Processing Equipment,* NFPA 75 [ANSI]. Such systems shall be in accordance with the applicable sections of NFPA Standards 72A, 72B, 72C, 72D, and 72E.

4-3.2 Where an automatic detection system is installed to sound the alarm and to actuate the extinguishing system, the system components shall be listed and manual operating means shall also be provided.

4-3.3 Local alarms shall be provided to operate upon actuation of the detection system, a manual pull station, or the fire protection system.

4-4 Portable Fire Extinguishers.

4-4.1 **General.** Portable fire extinguishers shall be provided in accordance with the requirements of the *Standard for the Installation of Portable Fire Extinguishers,* NFPA 10 [ANSI].

NOTE: See also 4-5, Hand Hose Lines.

4-4.2 Engine test facilities shall be classified by occupancy and hazard as follows:

(a) Areas containing fuel piping and equipment: Class B — Extra Hazard.

(b) Areas containing electronic equipment such as control rooms: Class C — Ordinary Hazard.

(c) Areas containing ordinary combustibles such as wood, paper, rubber, plastics, etc.: Class A — Ordinary Hazard.

4-5 Hand Hose Lines.

4-5.1* As an *alternate* to the provision of portable fire extinguishers as recommended in 4-3, hand hose line coverage of each support room, control room, engine test cell, test stand, or engine run-up enclosure may be provided for the class of combustibles indicated for each such space. Such hand hose installations shall be designed in accordance with the applicable sections of one of the following standards:

(a) *Standard on Carbon Dioxide Extinguishing Systems,* NFPA 12 [ANSI].

(b) *Standard for Foam Extinguishing Systems,* NFPA 11 [ANSI].

(c) *Standard on Synthetic Foam and Combined Agent Systems,* NFPA 11B [ANSI].

(d) *Standard for Dry Chemical Extinguishing Systems,* NFPA 17 [ANSI].

4-5.2 Each hose line station shall be placed such that it is easily accessible and so located that any area within the space to be protected may be covered by one or more hose lines.

4-6 Supplementary Systems for Engine Protection.

4-6.1 Carbon Dioxide Spurt Systems.

4-6.1.1 A carbon dioxide spurt system is a manually actuated fixed-pipe system designed to locally apply carbon dioxide to an engine on an intermittent basis and is an acceptable supplementary fire protection system for engine protection. The system shall be designed so that carbon dioxide can be discharged continuously by the operator. A spurt system may have its own agent supply or may 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.

4-6.1.2 Piping and fittings shall conform to the applicable provisions of the *Standard on Carbon Dioxide Extinguishing Systems,* NFPA 12 [ANSI].

4-6.1.3 The primary and connected reserve supply shall each be designed to provide a continuous discharge for a minimum of three minutes.

4-6.2 Steam Fire Protection Systems.

4-6.2.1.* A steam fire protection system designed to locally apply steam to an engine is an acceptable supplementary fire protection system for engine protection provided adequate quantities of steam are readily available at all times when a hazard exists. For the purpose of this standard, a steam fire protection system shall consist of a source, distribution piping, condensate drains, flow control valves, and discharge nozzles.

4-6.2.2 Piping for the distribution of steam from the source to the point of use shall conform to the *Code for Power Piping,* ANSI B31.1 as applicable.

4-6.2.3* The steam flow rate shall be sufficient to achieve a ratio of steam volume to total protected volume of 50 percent within 30 seconds. The steam supply shall be capable of maintaining that concentration until the fire has been extinguished.

4-6.2.4 The actuation of the steam fire extinguishing system shall be manual to avoid unwanted steam discharge which may adversely affect personnel or equipment. A manual control, independent of other energy sources, shall be provided to operate the system.

4-6.2.5 Means shall be provided for effective lockout of steam when required for personnel protection as well as for effective prevention of engine startup sequences when the steam system is locked out.

4-6.2.6 Steam condensate traps and lines shall be provided to bleed off liquid and allow only vapor to be directed to the protected area.

4-6.2.7 The system shall be inspected and tested at least semiannually.

Chapter 5 Employee Organization for Fire Safety

5-1 General. All personnel engaged in aircraft engine testing operations and all other persons regularly employed and working in or around test cells shall be instructed in fire prevention practices as part of their regular training. These personnel shall also be trained in the operation of all portable fire extinguishers and hose line systems provided in the area in which they work.

5-2 Operation of Fixed Fire Protection Systems. Selected personnel on each operational shift shall be trained in the operation of the fixed fire protection systems provided in the test facility. This training shall be accompanied by a comprehensive explanation of all features of such systems and the areas they protect.

5-3 Inspection and Maintenance of Fire Protection Equipment. Responsibility for fire protection equipment inspection and maintenance shall be assigned to key personnel.

Appendix A Explanatory Material

This Appendix is not a part of this NFPA Standard, but is included for information purposes only.

The following notes, bearing the same number as the text of the *Standard on Aircraft Engine Test Facilities* to which they apply, contain useful explanatory material and references to standards.

A-2-1 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: (a) combustible construction or unprotected openings at the same or higher elevation and (b) 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.

A-2-2.1 Other walls, ceilings and floor assemblies comprising the engine test facility should be fire resistive, protected noncombustible or noncombustible construction. The type of construction utilized in test buildings is determined to an extent by their proximity to main buildings or vital utilities. Normally the walls, ceilings, and floors are designed to resist a minimum internal pressure of 100 pounds per square foot.

A-2-2.5 Explosion Prevention, Venting and Suppression.

A-2-2.5.1 The degree of the explosion hazard in an engine test cell is affected by:

(a) The type of testing to be done (e.g., production testing, development/research testing, or maintenance testing).

(b) The characteristics of the fuel [e.g., aviation gasoline; JET B (JP-4); JET A or A-1 (JP-5 or JP-8)].

(c) The amount of airflow and whether or not it is ducted to the engine.

(d) The presence or absence of continuous ventilation.

(e) Fuel quantity in relation to volume of enclosure, maximum fuel pressure, temperature, and flow.

A-2-2.5.2 The potential damage because of an explosion will be in relation to:

(a) The designed pressure resistance of the structure.
(b) The amount of area utilized for inlet and exhaust air.
(c) The amount of explosion venting provided.
(d) The presence of explosion suppression equipment.

A-2-2.5.3 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 equipments, the type of construction and the configuration of the cell are some factors to be considered. *(See A-3-5.1.)* The net unobstructed area of engine test cell inlet and exhaust passages may be included in the venting area. Explosion venting may 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 the *Guide for Explosion Venting,* NFPA 68. Where the specific design or configuration of a test facility does not allow the use of explosion venting or very minimal explosion venting, consideration should be given to the protection of the structure of specialized equipments by the use of explosion suppression systems. Guidance for explosion suppression is provided in the *Standard on Explosion Prevention Systems,* NFPA 69 [ANSI].

A-3-1.1 Parts or foreign objects which are located in front of a turbine engine or in other locations where they may 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 proper safetying of parts and to eliminate foreign objects (e.g., tools, lockwire, nuts, bolts, washers, stones).

A-3-2.1 Test cells and support rooms may require drainage systems to effectively dispose of water used for engine washing, exhaust gas cooling system malfunctions, rain water, 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 ponding effect of high test cell air velocity.

A-3-2.2.3 Where deluge sprinkler systems are installed, the capacity of the drainage system may be determined by the sprinkler design rate increased by an appropriate correction for maximum main pressure. Exhaust gas cooling water rates need not be used for peak drainage if an adequate emergency shutoff system or a separate drainage system is provided.

A-3-2.2.4 All drain traps should be provided with an automatic reseal system.

A-3-3.2 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 resulting in damage to engine fuel lines with ensuing fire.

A-3-3.5 The failure of electric power supply to a test cell may deprive the operator of control of the engine resulting in possible engine damage and ensuing fire. Battery power or other means should be provided in order to properly operate the engine during such failures.

A-3-4.1 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-3-4.3 Direct cooling systems are preferred to systems which may utilize extensive ductwork which penetrate cell walls.

A-3-4.4 Test cell air inlet preheaters used to simulate hot inlet air conditions should preferably use steam or a liquid heat exchange medium. Auxiliary fans to allow pre- and post-operation purging prior to lightoff and after running may 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-3-5.1 Forced air ventilation at the rate of one cubic foot per minute per square foot of fresh air, per square foot of floor area should be provided in engine test areas when engines are not running.

A-3-6.2 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-3-6.3 The emergency fuel safety shutoff valve may also be operated by one or more of the following methods:

(a) Operation of the fire protection system.
(b) On actuation of heat sensing devices.
(c) Excess fuel flow.

A-3-7.1 Since air receivers are used, compressed air is usually a reliable source of power when electric energy is disrupted.

A-3-8.1 Hydraulic fluids with low fire hazard potential should be used. Such less hazardous hydraulic fluids include water-glycol, halogenated-hydrocarbon, phosphate-ester, or water-oil-emulsion types. Conversion of one hydraulic fluid to another requires thorough cleaning of the entire system and may also require changing of seals, packings, valves, or pumps to prevent leakage. Equipment and fluid manufacturers should be consulted for proper conversion procedures.

A-3-8.3 Flexible connectors and hoses should be used only where necessary.

A-3-9.3 Control instrumentation should be arranged so that its failure will not introduce a hazard. Where combustible pneumatic tubing is grouped in cabletrays or troughs, additional fire protection may be needed to prevent extensive damage to the tubing system.

A-4-1.1 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. Some of the factors pertinent to each agent are:

(a) Water. Water, particularly in spray form, is an effective agent in controlling or extinguishing kerosine-grade (e.g., JET A or A-1; JP-5 or JP-8) jet fuel fires. It 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. Disadvantages are drainage requirements and possible water damage to the test engine, to electrical devices, wiring and instrumentation.