NFPA®

770

Standard on Hybrid (Water and Inert Gas) Fire-Extinguishing Systems

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NFPA® 770

Standard on

Hybrid (Water and Inert Gas) Fire-Extinguishing Systems

2021 Edition

This edition of NFPA 770, *Standard on Hybrid (Water and Inert Gas) Fire-Extinguishing Systems*, was prepared by the Technical Committee on Hybrid (Water and Inert Gas) Fire Extinguishing Systems. It was issued by the Standards Council on March 15, 2020, with an effective date of April 4, 2020.

This edition of NFPA 770 was approved as an American National Standard on April 4, 2020.

Origin and Development of NFPA 770

Since the signing of the 1989 Montreal Protocol, the fire protection industry has innovated continually to find effective alternatives to Halons for special applications. This pursuit has resulted in the proliferation of fire protection systems using various extinguishing agents, including halocarbon clean agents, inert gas clean agents, water mist, and fire-extinguishing aerosols. Since each of these extinguishing agents has inherent limitations, it was recognized that some of these limitations could be offset by combining multiple agents. By the early 2000s, system manufacturers discovered that a hybrid media of fine water mist and inert gas agent provides a unique set of characteristics that are ideal for dispersion, extinguishment, and cooling.

Following the introduction of hybrid fire-extinguishing systems to the commercial market in 2008, the technical committees responsible for NFPA 750, *Standard on Water Mist Fire Protection Systems*, and NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, reviewed the technology for possible inclusion in the scopes of their standards. Both committees determined that either the gaseous component or the water component, respectively, introduced an element that was incompatible with the scope of their work.

The NFPA received the request for a new project on hybrid (water and inert gas) fire-extinguishing systems in September 2012. In March 2013, the NFPA Standards Council issued a request for public comment and received a positive response that a project should be initiated. Subsequently, the Fire Protection Research Foundation launched a research project to compare hybrid extinguishing with other technologies to determine whether any of the existing technical committees could take responsibility for the new topic. Based largely on research by FM Global, the final report, issued in May 2014, concluded that hybrid systems represent a separate and distinct technology from either water mist or clean agent systems and recommended that a new, separate document should be developed. In October 2014, the Standards Council approved the project and called for members. A committee was appointed and met for the first time in September 2015.

Over the course of the next two years, the Technical Committee on Hybrid (Water and Inert Gas) Fire Extinguishing Systems met five times to develop a draft standard. These early meetings included detailed and often contentious debates on important topics, such as the definition of the term *hybrid media*, the system design method, the application of design safety factors, system application testing and design validation, and hybrid media retention time.

In December 2017, the technical committee submitted a final draft to the Standards Council for public review, and the draft was placed in the Annual 2020 revision cycle. In accordance with NFPA's standards development process, the committee incorporated two rounds of public feedback to further refine and expand the standard.

This first edition of NFPA 770, *Standard on Hybrid (Water and Inert Gas) Fire-Extinguishing Systems*, is the result of years of volunteer service by intelligent, thoughtful, and dedicated professionals, including the technical committee members listed on the following page. However, the list does not fully reflect all of the key contributors who donated their time, knowledge, and experience to the process. In recognition of those volunteers, special thanks are extended to Thomas Wysocki, Hong-Zeng (Bert) Yu, Kevin Kelly, Steve Owens, Kevin Murray, Adam Tracy, and Robert Upson.

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

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

Committee Scope: This committee shall have primary responsibility for documents covering the design, installation, operation, and maintenance of hybrid (water and inert gas) fire extinguishing systems that use a combination of atomized water and inert gas to extinguish fire. This scope does not include systems that use only inert gas or only atomized water (water mist) to achieve extinguishment. It also does not include twin fluid water mist systems that use inert gas to propel and/or atomize water mist droplets without generating a significant inert gas concentration in the protected space.

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NFPA 770

Standard on

Hybrid (Water and Inert Gas) Fire-Extinguishing Systems

2021 Edition

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

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

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

Chapter 1 Administration

1.1 Scope. This standard contains the minimum requirements for the design, installation, acceptance, inspection, testing, and maintenance of hybrid fire-extinguishing systems that use a combination of atomized water and inert gas to extinguish fire.

1.1.1 The scope of this standard does not include systems that use only inert gas to achieve extinguishment. *(See NFPA 2001.)*

1.1.2 The scope of this standard does not include systems that use only atomized water (water mist) to achieve extinguishment. *(See NFPA 750.)*

1.1.3 The scope of this standard does not include twin fluid water mist systems that use inert gas to propel and/or atomize water mist droplets without generating a significant inert gas concentration in the protected space. *(See NFPA 750.)*

1.2* Purpose. This standard is prepared for the use and guidance of those charged with the purchasing, designing, installing, testing, inspecting, approving, listing, operating, or maintaining of hybrid fire-extinguishing systems, in order that such equipment will function as intended throughout its life.

1.3 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.3.1 Unless otherwise specified, the design, installation, and acceptance requirements of Chapter 4 through Chapter 13 shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard.

1.3.2 Unless otherwise specified, inspection, testing, and maintenance requirements in Chapter 14 shall apply to new and existing facilities, equipment, structures, or installations.

1.3.3 In those cases where the authority having jurisdiction determines that an existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard.

1.3.4 Requirements that are retroactively applied in accordance with this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

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

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

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

1.5 Units of Measurement. The units of measurement used in this standard are in accordance with Table 1.5.

1.5.1 Primary Units. Primary units of measurement are in accordance with the modernized metric system known as the International System of Units (SI), except where specific units are customary for industry practice.

1.5.2 Secondary Units and Conversions.

1.5.2.1 Secondary units of measurement, where provided, are in accordance with U.S. customary units (inch-pound units), except where specific units are customary for industry practice.

1.5.2.2 Where secondary units are not provided, converted values and converted trade sizes can be used.

1.5.2.3 Where extracted text contains values expressed in only one system of units, the values in the extracted text have been retained without conversion to preserve the values established by the responsible technical committee in the source document.

Table 1.5 Units of Measurement

Measurement	Primary Unit		Secondary Unit	
	Name	Symbol	Name	Symbol
Area, surface	square meters	m^2	square feet	ft^2
Distance, general	meters	m	feet	ft
Distance, orifice diameter/droplet size	micrometers	μm	inches	in.
Distance, pipe/tube dimensions	millimeters	mm	inches	in.
Mass, general	kilograms	kg	pounds (mass)	lb
Pressure, atmospheric	millimeters of mercury	mm Hg	inches of mercury	in. Hg
Pressure, system/nozzle	bar	bar	pounds per square inch	psi
Temperature	degrees Celsius	°C	degrees Fahrenheit	°F
Time, general	minutes	minutes	minutes	minutes
Time, discharge/extinguishment	seconds	seconds	seconds	seconds
Time, inspection interval	months	months	months	months
Time, maintenance interval	years	years	years	years
Volume, enclosure/inert gas	cubic meters	m^3	cubic feet	ft^3
Volume, water	liters	L	gallons	gal

1.5.3 Measurement of Pressure. All measurements of pressure are gauge values, unless otherwise noted.

1.5.4 Unit Application and Enforcement.

1.5.4.1* The values presented in this standard are expressed with a degree of precision that is appropriate for practical application and enforcement.

1.5.4.2* Either the primary units or secondary units are acceptable for satisfying the requirements in this standard.

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 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

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

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI Z535.2, *Standard for Environmental and Facility Safety Signs,* 2011, reaffirmed 2017.

2.3.2 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B1.20.1, *Pipe Threads, General Purpose, Inch*, 2013.

ASME B31.1, *Power Piping*, 2018.

Boiler and Pressure Vessel Code, 2017.

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

ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 2018.

ASTM A106/A106M, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*, 2018.

ASTM A269/A269M, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service,* 2015a.

ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes,* 2018.

ASTM A632, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service,* 2004, reapproved 2014.

ASTM A778/A778M, *Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products,* 2016.

ASTM A789/A789M, *Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service,* 2018.

ASTM B75/B75M, *Standard Specification for Seamless Copper Tube,* 2011.

ASTM B88, *Standard Specification for Seamless Copper Water Tube,* 2016.

ASTM B251/B251M, *Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube,* 2017.

2.3.4 CGA Publications. Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151-2923.

CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, 2013.

2.3.5 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designations*, 1994, reconfirmed 2015.

2.3.6 U.S. Government Publications. U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 29, Code of Federal Regulations, Part 1910, "Occupational Safety and Health Standards."

2.3.7 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2018 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2017 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* 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.

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions

3.3.1 Classes of Fire.

3.3.1.1 *Class A Fire.* A fire in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.

3.3.1.2 *Class B Fire.* A fire in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

3.3.1.3 *Class C Fire.* A fire that involves energized electrical equipment.

3.3.2 Deficiency. For the purposes of inspection, testing, and maintenance of fire protection systems, a condition that will or has the potential to adversely impact the performance of a system or portion thereof but does not rise to the level of an impairment.

3.3.2.1 *Critical Deficiency.* A deficiency that, if not corrected, can have a material effect on the ability of the fire protection system or unit to function as intended in a fire event. [**25,** 2017]

3.3.2.2 *Noncritical Deficiency.* A deficiency that does not have a material effect on the ability of the fire protection system or unit to function in a fire event, but correction is needed to meet the requirements of this standard or for the proper inspection, testing, and maintenance of the system or unit. [**25,** 2017]

3.3.3 Dv_f. A drop diameter such that the cumulative volume, from zero diameter to this respective diameter, is the fraction, f, of the corresponding sum of the total distribution. [**750**, 2019]

3.3.4 Enclosures.

3.3.4.1 *Normally Occupied Enclosure or Space.* An enclosure or space where one or more persons are present under normal conditions. [**2001,** 2018]

3.3.4.2 *Occupiable Enclosure or Space.* An enclosure or space that has dimensions and physical characteristics such that it could be entered by a person. [**2001,** 2018]

3.3.4.3 ***Unoccupiable Enclosure or Space.*** An enclosure or space that has dimensions and physical characteristics such that it could not be entered by a person. [**12,** 2018]

3.3.5 Fire Extinguishment. The complete extinction of a fire and all burning combustibles.

3.3.6 Hybrid Fire-Extinguishing System. A fire-extinguishing system capable of delivering hybrid media at the specified design rate and proportion.

3.3.7* Hybrid Media. An extinguishing media created by the simultaneous discharge of water mist and an inert gas agent in a controlled proportion from a common discharge device that results in an oxygen concentration less than 16 percent.

3.3.8 Hybrid Nozzle. A special purpose device containing one or more orifices specifically designed to deliver the hybrid media to the fire.

3.3.9* Impairment. A condition where a fire protection system or unit or portion thereof is out of order, and the condition can result in the fire protection system or unit not functioning in a fire event. [**25,** 2017]

3.3.9.1* ***Emergency Impairment.*** A condition where a fire protection system or portion thereof is out of order due to an unplanned occurrence, or the impairment is found while performing inspection testing or maintenance activities. [**25,** 2017]

3.3.9.2 ***Preplanned Impairment.*** A condition where a fire protection system or a portion thereof is out of service due to work planned in advance, such as revisions to the water supply or sprinkler system piping.

3.3.10 Inert Gas Agent. An agent that contains as primary components one or more of the gases helium, neon, argon, or nitrogen. Inert gas agents that are blends of gases can also contain carbon dioxide as a secondary component. [**2001,** 2018]

3.3.11 Inspection, Testing, and Maintenance.

3.3.11.1 ***Inspection.*** A visual examination of a system or portion thereof to verify that it appears to be in operating condition and is free of physical damage.

3.3.11.2 ***Maintenance.*** Work, including, but not limited to, repair, replacement, and service, performed to ensure that equipment operates properly.

3.3.11.3 ***Testing.*** Periodic operation of a component or system to determine operational status.

3.3.12 Lockout Valve. A manually operated valve that can be locked in the closed position and that is supervised.

3.3.13 Occupant Safety.

3.3.13.1 ***Lowest Observable Adverse Effect Level (LOAEL).*** The lowest concentration at which an adverse physiological or toxicological effect has been observed. [**2001,** 2018]

3.3.13.2 ***No Observed Adverse Effect Level (NOAEL).*** The highest concentration at which no adverse toxicological or physiological effect has been observed. [**2001,** 2018]

3.3.13.3 ***Sea Level Equivalent of Oxygen.*** The oxygen concentration (volume percent) at sea level for which the partial pressure of oxygen matches the ambient partial pressure of oxygen at a given altitude. [**2001,** 2018]

3.3.14 Pressure.

3.3.14.1 ***Maximum Allowable Working Pressure.*** The maximum pressure to which a system can be subjected without exceeding the pressure rating of any of its component parts.

3.3.14.2* ***Maximum Operating Pressure.*** The maximum pressure to which pipe or components will be subjected, determined at the maximum listed storage temperature.

3.3.15 System Design Methods.

3.3.15.1 ***Engineered Systems.*** Those systems for which flow rates, quantities of extinguishing agent, pipe size, pipe lengths, fittings, and size, type, and placement of nozzles are determined by individual design and calculation based on individual hazard volume, configuration, and fuel loading.

3.3.15.2* ***Pre-Engineered Systems.*** Those systems having predetermined flow rates and quantities of extinguishing agent with specific pipe sizes, maximum and minimum pipe lengths, flexible-hose specifications, number of fittings, and number, type, and locations of nozzles listed for specific hazards of predetermined volume and fuel loading.

3.3.16 Water Mist. A water spray for which the $Dv_{0.99}$ for the flow-weighted cumulative volumetric distribution of water droplets is less than 1000 μm within the nozzle operating pressure range. [**750,** 2019]

3.3.17 Working Plans. Documentation used for review and installation of the fire protection system. *(See Chapter 11.)*

Chapter 4 General Information

4.1 Use and Limitations.

4.1.1 Hybrid systems shall be permitted to be used to extinguish Class A, Class B, and Class C fires in accordance with the listing or fire test data that is acceptable to the authority having jurisdiction.

4.1.2 For Class C fires, electrical power to the protected hazard shall be shut down prior to the start of discharge, unless protection of energized electrical equipment is acceptable to the authority having jurisdiction.

4.1.3* Hybrid systems shall not be used on fires involving the following materials unless the hybrid media has been tested to the satisfaction of the authority having jurisdiction:

(1) Certain chemicals or mixtures of chemicals, such as cellulose nitrate and gunpowder, which are capable of rapid oxidation in the absence of air
(2) Chemicals capable of undergoing autothermal decomposition, such as certain organic peroxides and hydrazine
(3) Water-reactive materials, including, but not limited to, the following:
    (a) Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium
    (b) Metal hydrides
    (c) Metal alkoxides, such as sodium methoxide
    (d) Metal amides, such as sodium amide
    (e) Carbides, such as calcium carbide

(f) Halides, such as benzoyl chloride and aluminum chloride
(g) Hydrides, such as lithium aluminum hydride
(h) Oxyhalides, such as phosphorus oxybromide
(i) Silanes, such as trichloromethylsilane
(j) Sulfides, such as phosphorus pentasulfide
(k) Cyanates, such as methylisocyanate

4.1.4 Pre-Engineered Systems. All pre-engineered systems shall be installed to protect hazards within the limitations that have been established by the listing. Provisions of this standard regarding personnel safety, commissioning, inspection, testing, and maintenance shall apply.

4.1.5 Temperature Limits. Hybrid system equipment shall be designed to function from 4°C to 54°C (40°F to 130°F) or marked to indicate temperature limitations.

4.2* Safety Considerations.

4.2.1 Unnecessary exposure to atmospheres flooded by a hybrid system resulting in low oxygen atmospheres shall be avoided.

4.2.2 Suitable safeguards shall be provided to ensure prompt evacuation from and prevent entry into hazardous atmospheres and also to provide means for prompt rescue of any trapped personnel. Safety items such as personnel training, warning signs, discharge alarms, self-contained breathing apparatus (SCBA), evacuation plans, and fire drills shall be considered.

4.2.3 In the event of a system discharge, unprotected personnel shall not enter the space until it has been ventilated and it is determined that the atmosphere is safe for unprotected personnel to enter.

4.2.4 Before system cylinders are handled or moved, the following steps shall be taken:

(1) Cylinder outlets shall be fitted with anti-recoil devices, cylinder caps, or both whenever the cylinder outlet is not connected to the system pipe inlet.
(2) Actuators shall be disabled or removed before cylinders are removed from retaining bracketing.

4.2.4.1 Safe handling procedures shall be followed when transporting system cylinders.

4.2.4.2 Equipment designed for transporting cylinders shall be used. When dollies or carts are used, cylinders shall be secured.

4.2.4.3 The system manufacturer's service procedures shall be followed for specific details on system operation, maintenance, and safety considerations.

4.3 Use Restrictions

4.3.1 Normally Occupied Areas. Hybrid systems shall be permitted in normally occupied areas only where one of the following conditions is applicable:

(1) Where exposure times to sea level equivalent oxygen concentrations above 12 percent can be limited to 5 minutes
(2) Where exposure times to sea level equivalent oxygen concentrations above 10 percent can be limited to 3 minutes

4.3.2 Normally Unoccupied Areas. Hybrid systems with sea level equivalent oxygen concentrations above 8 percent shall be permitted in normally unoccupied areas when exposure time can be limited to 30 seconds.

4.3.3 Unoccupiable Areas. Hybrid systems with sea level equivalent oxygen concentrations of 8 percent or lower shall be permitted in unoccupiable areas.

4.3.4* An egress time study shall be performed to verify that the maximum exposure time limits in 4.3.1 and 4.3.2 are achieved.

4.3.5* Altitude Considerations. In considering the oxygen concentration developed by a hybrid system, the effect of altitude on oxygen concentration shall be considered for elevations that vary from sea level by more than 915 m (3000 ft).

4.3.6 Where the resulting sea level equivalent oxygen concentration is below the permitted limits for a system protecting a normally occupied or occupiable enclosure or space, the following safeguards shall be provided:

(1) Predischarge alarm
(2) Predischarge delay
(3) Warning signs
(4) Supervised lockout valves

4.4 Qualifications. Hybrid systems shall be designed, installed, serviced, and maintained by personnel that are trained and certified for the service performed by the manufacturer or an organization acceptable to the authority having jurisdiction.

Chapter 5 Components

5.1 Water Supply.

5.1.1* Quality. The water supply for a hybrid system shall be taken from a source that is equivalent in quality to a potable source with respect to particulate and dissolved solids.

5.1.2* Filters and Strainers for Nozzles. A filter or strainer shall be provided at the supply side of each nozzle, unless permitted to be omitted by the authority having jurisdiction.

5.1.3 Filters and Strainers for Water Supply Connections.

5.1.3.1* A filter or a strainer shall be provided at each water supply connection.

5.1.3.2 Strainers shall be provided with a cleanout port.

5.1.3.3 Strainers shall be accessible.

5.1.4 Filter Rating or Strainer Mesh Openings. The maximum filter rating or strainer mesh opening shall not be greater than 80 percent of the minimum nozzle waterway dimension.

5.2* Inert Gas Agent Supply. The inert gas agent supply shall be at least 99.9 percent pure with a water content <0.005 percent.

5.3 Storage Containers.

5.3.1 The inert gas agent and water storage containers shall be permitted to be cylinders, tubes, or fabricated tanks.

5.3.1.1 Storage containers shall be manufactured from a material or provided with an interior coating that is compatible with the material being stored.

5.3.1.2 Water storage containers shall be fabricated of corrosion-resistant material or be provided with a corrosion-resistant interior coating.

5.3.2 Storage containers and accessories shall be located and arranged to facilitate inspection, testing, recharging, and other maintenance.

5.3.3 Storage containers shall not be located where they are subject to severe weather conditions or to mechanical, chemical, or other damage.

5.3.3.1 Where exposure to severe weather conditions or to mechanical, chemical, or other damage cannot be avoided, approved safeguards or enclosures shall be provided.

5.3.3.2 External heating or cooling shall be permitted to be used to keep the temperature within the listed temperature range.

5.3.4 Storage containers shall be installed and mounted in accordance with the manufacturer's installation manual.

5.3.5 Each pressurized container or cylinder shall be provided with a safety device to relieve excess pressure.

5.3.6 A reliable means shall be provided to indicate the pressure in all storage containers that will be pressurized.

5.3.7 Water tanks shall be further supervised for the following conditions:

(1) Water level
(2) Water temperature (for tanks located in unheated areas)

5.3.8 A reliable means shall be provided to visually indicate the level in all water storage containers.

5.3.9 Each storage container shall have a permanent nameplate or other permanent marking that indicates the following:

(1) For inert gas agent containers, the agent, pressurization level of the container, and nominal agent volume at standard temperature and pressure (STP)
(2) For water containers, pressurization level of the container and nominal water volume

5.3.10 Containers meant to be transported while pressurized shall meet the requirements of the national codes for the country of use.

5.3.11 The design pressure for containers meant to be transported while pressurized shall be suitable for the maximum pressure developed at the maximum listed temperature.

5.3.12 Containers not covered in 5.3.10 shall be designed, fabricated, inspected, certified, and stamped in accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code.*

5.3.13 The design pressure for containers not covered in 5.3.10 shall be suitable for the maximum pressure developed at the maximum listed temperature.

5.4 Pipe, Fittings, and Valves.

5.4.1 General.

5.4.1.1 Pipe, tubing, fittings, and valves shall be compatible with the manufacturer's hardware and media, as identified in the listing and installation instructions, and with the intended environment.

5.4.1.2 Pipe or tube shall meet or exceed one of the standards in Table 5.4.1.2, except as permitted by 5.4.1.3 or 5.4.1.4.

5.4.1.3 Pipe used exclusively to flow inert gas agent shall be permitted to be black steel, in accordance with ASTM A53/A53M or A106/A106M.

5.4.1.4 Where the pipe or tube identified in Table 5.4.1.2 or 5.4.1.3 is not suitable for the environmental conditions, other pipe materials that are manufactured to ASTM standards shall be permitted where the pipe or tube is investigated for compatibility with the system and the environment.

5.4.2 Pressure Rating Design Requirements.

5.4.2.1* Each piping network shall be designed to the maximum pressure and temperature to which it could be subjected within the system listing parameters.

5.4.2.2 The minimum design pressure for piping downstream of a pressure-reducing device shall be determined from the maximum anticipated pressure in the downstream piping as predicted by system flow calculations.

Table 5.4.1.2 Pipe or Tube Standards

Materials and Dimensions and Standard Titles	Standard No.
Copper Tube (Drawn, Seamless)	
*Standard Specification for Seamless Copper Tube**	ASTM B75/B75M
*Standard Specification for Seamless Copper Water Tube**	ASTM B88
Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B251/B251M
Stainless Steel	
Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service	ASTM A269/A269M
Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service	ASTM A632
Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products	ASTM A778/A778M
Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service	ASTM A789/A789M
Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes	ASTM A312/A312M
Galvanized Steel Pipe	
Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	ASTM A53/A53M
Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service	ASTM A106/A106M

*Denotes tube suitable for bending *(see 12.5.7)* according to ASTM standards.

5.4.3 Pressure Relief.

5.4.3.1* A listed pressure relief device shall be installed in the sections of pipe where the pressure could exceed the maximum allowable working pressure.

5.4.3.2 The pressure relief device shall operate at a pressure not exceeding the maximum allowable working pressure.

5.4.4 Pipe Requirements.

5.4.4.1 Wherever the word *pipe* is used, it shall be understood also to mean *tube*.

5.4.4.2 Pipe shall be of material having physical and chemical characteristics such that its integrity under stress can be predicted with reliability.

5.4.4.2.1 Pipe shall have minimum working pressure ratings based on the maximum operating pressure of the system.

5.4.4.2.2* The thickness of the piping shall be calculated using the formula given in ASME B31.1.

5.4.5 Fittings and Piping Connections.

5.4.5.1 Fittings shall conform to ASME B31.1 or an equivalent standard and be of material having physical and chemical characteristics such that its integrity under stress can be predicted with reliability.

5.4.5.2 The fittings shall have corrosion resistance equal to the connected piping.

5.4.5.3 Fitting materials shall be compatible with the connected pipe to prevent galvanic corrosion at the connection joint.

5.4.5.4 Fittings shall have a minimum rated working pressure equal to or greater than the maximum system operating pressure or as otherwise listed or approved.

5.4.5.5 Cast-iron fittings shall not be used.

5.4.5.6 All threads used in joints and fittings shall conform to ASME B1.20.1 or ISO 7-1.

5.4.5.7 Welding and brazing alloys shall have a melting point above 538°C (1000°F).

5.4.5.8 Where copper, stainless steel, or other suitable tubing is joined with compression-type fittings, the manufacturer's pressure and temperature ratings of the fitting shall not be exceeded.

5.4.5.9 Where copper tubing is joined by soldering, the joining material used shall be adequate for the system listing temperature and piping network maximum pressure.

5.4.5.10 Grooved fittings shall be permitted provided they are listed for the pressure and temperature requirements and meet the corrosion resistance requirements of the piping network.

5.4.6 Strainers or Filters.

5.4.6.1 Strainers or filters shall be installed in the water distribution system per the manufacturer's listed design, installation, and maintenance manual.

5.4.6.2 Strainers and filters shall be listed or approved for the intended use.

5.4.7 Valves.

5.4.7.1 All valves shall be listed or approved for the intended use.

5.4.7.2 For flanged valves, the class and style of flanges required to match the valve's flanged connection shall be used.

5.4.7.3 Valves shall be protected against mechanical, chemical, or other damage.

5.4.7.4 Special corrosion-resistant materials or coatings shall be used in corrosive atmospheres.

5.4.7.5 Where directional valves are used for multihazard protection, the directional valves shall be listed or approved for the intended purpose.

5.4.7.6 Where directional valves are used for multihazard protection, the control equipment shall be specifically listed for the number, type, and operation of those valves.

5.4.8 Lockout Valve. A manually operated lockout valve shall be provided on all systems to prevent the flow of inert gas agent and water to the discharge device(s) during maintenance of the system.

5.4.8.1 The lockout valve shall be located in accordance with the manufacturer's instructions.

5.4.8.2 The lockout valve shall provide a supervisory signal when it is not in the open position.

5.4.9 Drain.

5.4.9.1 A low-point drain shall be provided in the water discharge pipeline to permit draining any residual water from the pipeline.

5.4.9.2 Where multiple low points in a water discharge piping network occur, a drain shall be provided at each occurrence.

5.4.9.3 Each drain valve shall either provide a supervisory signal when it is not in the closed position or be lockable in the closed position.

5.4.10 Identification of Valves.

5.4.10.1 All control, drain, and test connection valves shall be provided with permanently marked, weatherproof, metal or rigid plastic identification signs.

5.4.10.2 The sign shall be secured with corrosion-resistant wire, chain, or other approved means.

5.4.11 Pipe Hangers/Supports.

5.4.11.1 All references to hangers shall include supports.

5.4.11.2* Hangers shall be installed throughout the piping network to prevent excessive bending and shear stresses in both the horizontal and vertical axes during system discharge.

5.5 Hybrid Nozzles.

5.5.1 Hybrid nozzles shall be listed for the intended use.

5.5.2 Listing criteria shall include flow characteristics, orientation, area coverage, minimum and maximum spacing between nozzles, height limits, droplet size distribution, and operating pressure.

5.5.3 The hybrid nozzle shall produce water droplets with a $Dv_{0.99}$ of 200 μm (0.0079 in.) at the minimum nozzle operating pressure.

5.5.4 Where corrosive conditions are known to exist, corrosion-resistant materials or coatings applied by the manufacturer shall be required to protect the nozzle.

5.5.5 Hybrid nozzles shall be permanently marked to identify the manufacturer as well as the type and size of the orifices.

5.6 Detection, Actuation, Alarm, and Control Systems.

5.6.1 Detection, actuation, alarm, and control systems shall be installed, tested, and maintained in accordance with *NFPA 72* and *NFPA 70*.

5.6.2 Automatic detection and actuation shall be used.

5.6.3 Actuation by only manual means shall be permitted if acceptable to the authority having jurisdiction.

5.6.4 Adequate and reliable primary and 24-hour minimum standby sources of energy shall be used to provide for operation of the detection, signaling, control, and actuation requirements of the system.

5.6.5 Automatic Detection.

5.6.5.1 Automatic detection shall be by any listed method or device capable of detecting and indicating heat, flame, smoke, combustible vapors, or an abnormal condition in the hazard, such as process trouble, that is likely to produce fire.

5.6.5.2 Where a new hybrid system is being installed in a space that has an existing detection system, an analysis shall be made of the detection devices to ensure that the detection system is in good operating condition, will respond promptly to a fire situation, and is compatible with the releasing service fire alarm control unit.

5.6.6 Operating Devices.

5.6.6.1 Operating devices shall include agent-releasing devices or valves, discharge controls, and shutdown equipment necessary for successful performance of the system.

5.6.6.2 Operation shall be by a listed mechanical, electrical, or pneumatic means with an adequate and reliable source of energy.

5.6.6.3 All devices shall be designed for the service they will encounter and shall not readily be rendered inoperative or susceptible to accidental operation.

5.6.6.4 All devices shall be located, installed, or suitably protected so that they are not subject to mechanical, chemical, or other damage that would render them inoperative.

5.6.6.5 A means of manual release of the system shall be provided.

5.6.6.5.1 Manual release shall be accomplished by a mechanical manual release or by an electrical manual release when the control equipment monitors the battery voltage level of the standby battery supply and provides a low-battery signal.

5.6.6.5.2 The release shall cause simultaneous operation of automatically operated valves controlling agent release and distribution.

5.6.6.5.3 Where mechanical system actuation is possible, a discharge pressure switch or a flow switch shall provide an alarm-initiating signal to the releasing panel.

5.6.6.5.4 A means of manual release shall not be required for automatic systems when the hazard being protected is unoccupiable, and the hazard is in a remote location where personnel are not normally present.

5.6.6.5.4.1 The normal manual control(s) for actuation shall be located for easy accessibility at all times, including at the time of a fire.

5.6.6.5.4.2 The manual control(s) shall be of distinct appearance and clearly recognizable for the purpose intended.

5.6.6.5.4.3 All manual operating devices shall be identified as to the hazard they protect.

5.6.6.5.4.4 Operation of any manual control shall cause the complete system including any required auxiliary functions to operate as designed.

5.6.7 Electric Actuator Supervision.

5.6.7.1 Removal of an electric actuator from the agent storage container discharge valve that it controls shall result in an audible and visual indication of system impairment at the system releasing control panel.

5.6.7.2 Removal of an electric actuator from the selector valve it controls shall result in an audible and visual indication of system impairment at the system releasing control panel.

5.6.8 Operating Alarms and Indicators.

5.6.8.1 Alarms or indicators or both shall be used to indicate the operation of the system, hazards to personnel, or failure of any supervised device.

5.6.8.1.1 The type (audible, visual, or olfactory), number, and location of the devices shall be such that their purpose is satisfactorily accomplished.

5.6.8.1.2 The extent and type of alarms or indicator equipment or both shall be approved.

5.6.8.2* Audible and visual predischarge alarms shall be provided within the protected area of normally occupied or occupiable spaces to give positive warning of impending discharge.

5.6.8.2.1 The time delay shall be sufficient to allow personnel evacuation prior to discharge.

5.6.8.2.2 The operation of the notification appliances shall be continued after hybrid media discharge, until the alarm has been acknowledged and appropriate actions have been taken.

5.6.8.2.3 For hazard areas subject to fast growth fires, where the provision of a predischarge alarm and time delay would seriously increase the threat to life and property, the predischarge alarm and time delay shall be permitted to be eliminated.

5.6.8.3 Audible and visual alarms associated with the hybrid system shall be distinct from all other alarms, including the building fire alarm system.

5.6.8.4* Abort switches shall be permitted only where approved by the authority having jurisdiction.

5.6.8.4.1 Abort switches shall be located within the protected area, near the means of egress for the area.

5.6.8.4.2 The abort switch shall be of a type that requires constant manual pressure to cause abort.

5.6.8.4.3 In all cases, the normal manual control and the manual emergency control shall override the abort function.

5.6.8.4.4 Operation of the abort function shall result in both audible and distinct visual indication of system impairment.

5.6.8.4.5 The abort switch shall be clearly recognizable for the purpose intended.

5.6.8.5 Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

5.6.8.6 Warning and instruction signs at entrances to and inside protected areas shall be provided.

5.6.8.6.1 Warning signs shall be affixed in a conspicuous location in every protected space; at every entrance to protected spaces; at every remote manual actuation station; at every entrance to inert gas storage rooms; and where inert gas might collect and result in a reduced oxygen atmosphere in the event of a discharge from a safety device or control panel leak.

5.6.8.6.2 The safety sign format and color and the letter style of the signal words shall be in accordance with ANSI Z535.2, as shown in Figure 5.6.8.6.2(a) through Figure 5.6.8.6.2(d).

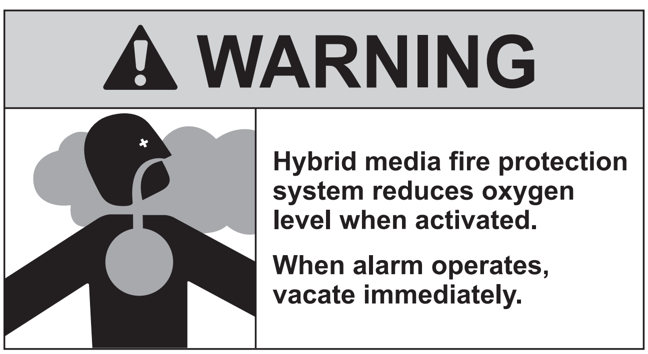

FIGURE 5.6.8.6.2(a) Sign in Every Protected Space.

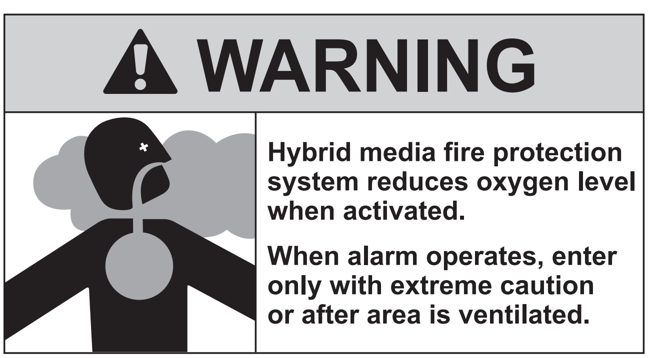

FIGURE 5.6.8.6.2(b) Sign at Every Entrance to Protected Space.

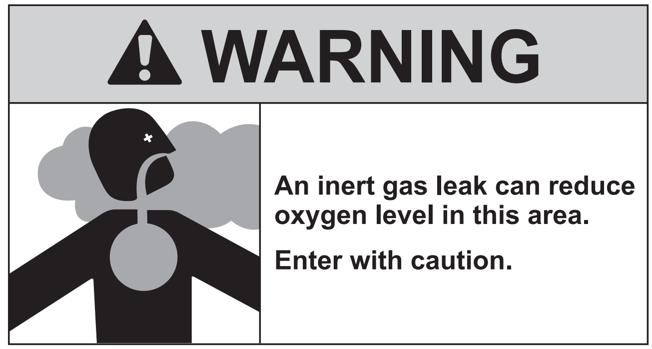

FIGURE 5.6.8.6.2(c) Sign at Every Entrance to Inert Gas Storage Rooms or Areas where Inert Gas Could Collect in the Event of a Discharge from a Safety Device or Control Panel Leak.

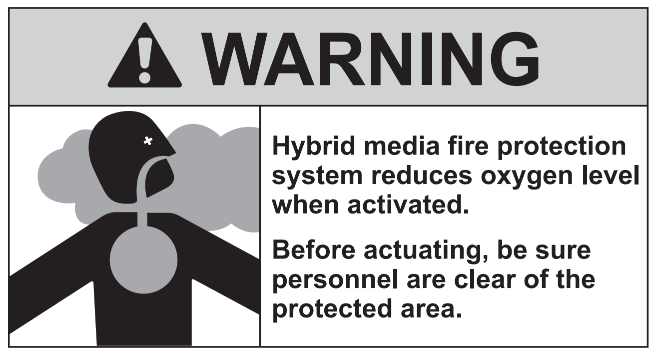

FIGURE 5.6.8.6.2(d) Sign at Every Remote Manual Actuation Station.

5.6.9 Control Equipment.

5.6.9.1* The control equipment shall supervise the detection, manual controls, actuating devices, and associated wiring and, when activated, cause actuation of the system and operation of any required auxiliary functions.

5.6.9.2 The control equipment shall be specifically listed for compatibility with the number and type of actuating devices.

5.6.9.3 All circuitry that is monitoring or controlling the hybrid fire-extinguishing system shall be electrically supervised in accordance with *NFPA 72*.

5.6.9.4 Sensors providing feedback for system operation shall be identified as such on the sensor or an adjacent surface.

5.6.9.5 Conductors providing feedback for system operation shall be in accordance with the manufacturer's specifications.

5.6.9.6* Where pneumatic control equipment is used, the pneumatic lines shall be protected against crimping and mechanical damage.

5.6.9.7 Where mechanical system operation is possible, a discharge pressure switch shall be installed on the system piping to provide an alarm-initiating signal to the releasing panel.

5.6.9.8 Disconnect Switch. To avoid unwanted discharge of an electrically actuated hybrid fire-extinguishing system, a supervised disconnect switch shall be provided.

5.6.9.8.1 The disconnect switch shall interrupt the releasing circuit to the suppression system.

5.6.9.8.2 The disconnect switch shall cause a supervisory signal at the releasing control unit.

5.6.9.8.3 The disconnect switch shall be secured against unauthorized use by one of the following methods:

(1) Locate inside a lockable releasing control panel
(2) Locate inside a lockable enclosure
(3) Require a key for activation of the switch

5.6.9.8.4 When the disconnect switch requires a key for activation, the access key shall not be removable while disconnected so the suppression system can be quickly returned to the operational condition in the event of a fire.

5.6.9.8.5 Suppression system disconnect achieved via software programming shall not be acceptable for use in lieu of a physical disconnect switch.

5.6.9.8.6 The disconnect switch shall be listed or be an integrated component of listed equipment.

Chapter 6 Application and Fire Test Protocols

6.1* General.

6.1.1 Listing or Approval. Hybrid extinguishing systems shall be designed and installed for the specific hazards and protection objectives identified in the listing or in accordance with criteria approved by the authority having jurisdiction.

6.1.2 Application Characteristics. The enclosure variables, as applicable, and hazard classification of the specific application shall be consistent with the listing or in accordance with criteria approved by the authority having jurisdiction.

6.1.3 Application Evaluations. An evaluation of the enclosure geometry (as applicable), the fire hazards, and the system variables described in this chapter shall be performed to ensure that the system design and installation are consistent with the listing or in accordance with criteria approved by the authority having jurisdiction.

6.1.4 Pre-Engineered Systems. Pre-engineered hybrid extinguishing systems for total flooding applications shall not be extrapolated beyond the enclosure volume, ceiling height, ventilation rate, and number of nozzles tested, unless dimensions of the enclosure are such that additional nozzles are required to maintain nozzle spacing.

6.2* Listing or Approval Evaluations.

6.2.1* General. Listing or approval of hybrid extinguishing systems shall be based on a comprehensive evaluation designed to include fire test protocols, system component test procedures, and a review of the manufacturer's design, installation, operation, and maintenance manual.

6.2.2* Fire Test Protocols. Fire test protocols shall be designed to address performance objectives of the application specified in the listing or in accordance with criteria approved by the authority having jurisdiction and the application parameters described in Section 6.4.

6.2.3 Application Parameters.

6.2.3.1 Application parameters shall be the features that define an application.

6.2.3.2* Application parameters shall include enclosure variables, fire hazard properties, and occupancy status, with consideration for specific system performance objectives.

6.2.4 Applicability. Fire test protocols shall be designed to replicate the range of the application parameters associated with a particular hazard.

6.2.5 Testing. Test protocols shall be conducted to verify the working limits and installation parameters of the system and its components, as described in the manufacturer's design and installation manual.

6.2.6 Design, Installation, Operation, and Maintenance Manual.

6.2.6.1 The system design and installation manual evaluated by the tests shall identify the working limits and parameters of the system, the fire hazards, and the range of enclosure variables, as applicable, consistent with the listing.

6.2.6.2 The system design and installation manual evaluated by the tests shall include design, installation, acceptance, testing, inspection, and maintenance procedures in accordance with the requirements of this standard and the manufacturer's recommendations.

6.3 Performance Objectives. The firefighting performance objective of a hybrid extinguishing system shall be to achieve fire extinguishment with a duration of protection designed to prevent reignition. *(See 3.3.5, Fire Extinguishment.)*

6.4 Application Parameters.

6.4.1* Total Flooding Enclosure Variables. Enclosure variables shall include the geometry of the enclosure, unclosable opening(s), and the ventilation conditions in the enclosure.

6.4.1.1 Enclosure Geometry. The enclosure geometry, as applicable, including floor area, volume, ceiling height, and aspect ratio, shall be considered when designing such parameters as nozzle locations, system flow rate, and total hybrid media use needs of the system.

6.4.1.2 Ventilation. Ventilation considerations shall include both natural and forced ventilation parameters.

6.4.1.2.1* Natural Ventilation.

6.4.1.2.1.1* The number, size, and location of the openings in the space shall be addressed in the design and installation of the system.

6.4.1.2.1.2* In some cases, special precautions shall be given to minimize the effects of openings in the space.

6.4.1.2.2 Forced Ventilation.

6.4.1.2.2.1 The magnitude of the forced ventilation in the enclosure shall be addressed in the design and installation of the hybrid extinguishing system.

6.4.1.2.2.2 In some cases, consideration shall be given to shutting down the forced ventilation prior to hybrid system activation.

6.4.2 Fire Hazard Classification. Fire hazards shall be classified as follows:

(1) Specific total flooding application systems in accordance with Chapter 8 and this section
(2) Specific local application systems in accordance with Chapter 9 and this section

6.4.2.1 Combustible Loading.

6.4.2.1.1 A fire hazard analysis shall be conducted to determine both the design parameters of the hybrid extinguishing system and the type of detection and activation scheme employed by the system.

6.4.2.1.2 The system shall be based on the fuel type, combustible loading, and anticipated fire growth rate as well as the desired firefighting performance objectives.

6.4.2.2 Fuel Type.

6.4.2.2.1 Fire Hazard Classification. The fire hazard classification shall be directly related to the type and quantity of the fuel present in a space.

6.4.2.2.2 Fire Hazard Characteristics. The ease of ignition and reignition of the fuel, the fire growth rate, and the difficulty of achieving extinguishment shall be considered when selecting or designing a hybrid extinguishing system.

6.4.2.2.3 Class A Fires.

6.4.2.2.3.1 Fuel loading and configuration shall be considered when selecting and designing a system to protect a space or area containing Class A materials.

6.4.2.2.3.2 Consideration shall be given to the potential for deep-seated fires as well as to the potential for smoldering fires.

6.4.2.2.4 Class B Fires.

6.4.2.2.4.1 The hazard(s) associated with Class B fires shall be related primarily to the fuel loading, fuel configuration, flashpoint, and burning rate of the fuel.

6.4.2.2.4.2 Preburn time, which affects the overall characteristics of the fire, shall be evaluated.

6.4.2.2.4.3 Class B fires shall be grouped into the following categories:

(1) Two-dimensional pool fires
(2) Three-dimensional spray and running fuel fires

6.4.2.2.4.4 The parameters associated with each Class B category shall be as follows:

(1) Class B two-dimensional fires, as follows:
    (a) Fuel loading and configuration
    (b) Fuel flashpoint
    (c) Preburn time pool/spill size
(2) Class B three-dimensional fires, as follows:
    (a) Fuel loading and configuration
    (b) Fuel flashpoint
    (c) Preburn time
    (d) Cascade/running fuel fires
    (e) Fuel flow rate
    (f) Fire configuration
    (g) Spray fires
    (h) Fuel line pressure
    (i) Fuel spray angle
    (j) Fuel spray orientation
    (k) Reignition sources

6.4.2.2.4.5 When designing and installing hybrid fire extinguishing systems to protect Class B hazards, the parameters specified in 6.4.2.2.4.4 shall be considered.

6.4.2.2.5 Class C Fires. Electrical conductivity of water and hybrid media shall be addressed when considering applications where the primary fire is a Class C fire.

6.4.2.2.6 Combination Fires. Combinations in fuel loadings and hazards shall be addressed.

6.4.3 Fire Location. The location of the fuel in the space shall be considered when selecting and designing a hybrid fire extinguishing system, including the following:

(1) Fuel located at higher elevations in the space
(2) Fuel located in close proximity to vent openings
(3) Fuel located in the corners of the space
(4) Fuel stacked against walls

6.4.4 Obstructions and Shielding.

6.4.4.1 Hybrid media nozzles shall be positioned to distribute hybrid media to all locations in the area or around the object being protected.

6.4.4.2 The presence of obstructions and the potential for shielding of spray patterns shall be evaluated to ensure that the system performance is not affected.

6.5 Flooding Factor. The flooding factor, *X*, as used in the equation in 8.4.1, shall be determined for the specific fuel by testing in accordance with Section 8.3.

Chapter 7 System Design Requirements

7.1 General. Hybrid extinguishing systems shall be designed and installed for the specific hazards and protection objectives specified in the listing or in accordance with criteria approved by the authority having jurisdiction.

7.2 Pipe Network Layout and Design.

7.2.1 Pipe shall be sized for the intended system flow rates in accordance with the manufacturer's manual.

7.2.2 Fixtures and connections shall be provided to facilitate system testing in accordance with Chapters 12, 13, and 14.

Chapter 8 Design Requirements for Total Flooding Systems

8.1 General.

8.1.1 Description. A total flooding system shall consist of a fixed supply of hybrid media permanently connected to a fixed pipe network with fixed nozzles arranged to discharge the hybrid media into an enclosed space or an enclosure about the hazard.

8.1.2 Uses. A total flooding system shall be used where there is a permanent enclosure around the hazard that enables the required density of hybrid media to be discharged for extinguishment and prevent fire re-ignition for the required period of time or for a time period sufficient to allow for response by trained personnel.

8.2 Enclosure Requirements.

8.2.1 Enclosure Strength and Pressure Relief.

8.2.1.1 The protected enclosure shall have the structural strength and integrity necessary to contain the agent discharge.

8.2.1.2 An estimate of the maximum positive pressure, relative to ambient pressure, expected to develop upon discharge of the agent shall be determined.

8.2.1.3 If the developed pressures present a threat to the structural strength of the enclosure, additional venting shall be provided to prevent excessive pressures.

8.2.1.4 Designers shall consult the system manufacturer's recommended procedures relative to enclosure venting.

8.2.2* Enclosure Integrity and Loss of Hybrid Media. The concentration of hybrid media shall be maintained for the specified duration of protection. *(See Section 8.6.)*

8.2.3 Forced-Air Ventilation Systems and Loss of Hybrid Media.

8.2.3.1* Forced-air ventilation systems shall be shut down or closed automatically where their continued operation would adversely affect the performance of the fire-extinguishing system or result in propagation of the fire.

8.2.3.2 The volume of a recirculating ventilation system and associated ductwork shall be considered part of the total hazard volume when determining the quantity of hybrid media.

8.2.3.3 Where a non-recirculating ventilation system is not shut down, additional hybrid media shall be introduced to maintain the required design application density.

8.3 System Performance Characteristics.

8.3.1 Protection of Class A, Class B, and Class C Hazards. The following characteristics of the system shall be determined for a given fuel or hazard type by performance-based testing or listing:

(1) Inert gas agent discharge rate of the hybrid nozzle, $R_{D,IG}$
(2) Water discharge rate of the hybrid nozzle, R_{D,H_2O}
(3) Intended dry-basis concentration of oxygen at 21°C (70°F) ambient temperature, C_{oxygen}
(4)* Time to extinguishment
(5) Maximum time to discharge the minimum volume of inert gas agent, t_D
(6) Maximum protected volume per hybrid nozzle
(7) Maximum ceiling height
(8) Maximum coverage area dimensions (width × length) per hybrid nozzle
(9) Minimum clearance to walls
(10) Minimum and maximum clearance to ceiling

8.3.2 Protection of Mixed Hazards. For combinations of fuel or hazard types, the system design characteristics shall be determined by the fuel or hazard type that requires the most restrictive design parameters, unless tests are performed on the actual combination of fuel or hazard types.

8.4 Hybrid Media Quantity.

8.4.1 The minimum quantity of inert gas agent required shall be calculated in accordance with the following equation:

[8.4.1]

$$Q_{min} = F_{S,IG} \cdot V_{enc} \cdot \left(\frac{294.4}{273 + T_{min}}\right) \cdot X \cdot F_{atm}$$

where:
Q_{min} = minimum volume of inert gas agent to be added (m^3)
$F_{S,IG}$ = inert gas agent safety factor
V_{enc} = volume of the enclosure (m^3)
T_{min} = minimum expected ambient enclosure temperature (°C)
X = flooding factor at 21°C ambient temperature (m^3/m^3)
F_{atm} = atmospheric correction factor

8.4.1.1 The inert gas agent safety factor, $F_{S,IG}$, shall be 1.2.

8.4.1.2* The flooding factor, *X*, shall be determined by test for the specific fuel or hazard type, per Section 8.3.

8.4.1.3 The design quantity of the inert gas agent shall be adjusted in accordance with Table 8.4.1.3 to compensate for ambient pressures that vary more than 11 percent [equivalent to approximately 915 m (3000 ft) of elevation change] from standard sea level pressures [760 mm Hg at 0°C (29.92 in. Hg at 70°F)].

Table 8.4.1.3 Atmospheric Correction Factors, F_{atm}

Equivalent Altitude		Enclosure Pressure (Absolute)		Atmospheric Correction Factor
ft	km	psi	mm Hg	
−3,000	−0.92	16.25	840	1.11
−2,000	−0.61	15.71	812	1.07
−1,000	−0.30	15.23	787	1.04
0	0.00	14.70	760	1.00
1,000	0.30	14.18	733	0.96
2,000	0.61	13.64	705	0.93
3,000	0.91	13.12	678	0.89
4,000	1.22	12.58	650	0.86
5,000	1.52	12.04	622	0.82
6,000	1.83	11.53	596	0.78
7,000	2.13	11.03	570	0.75
8,000	2.45	10.64	550	0.72
9,000	2.74	10.22	528	0.69
10,000	3.05	9.77	505	0.66

8.4.2 The system discharge rate shall be calculated in accordance with the following equation:

[8.4.2]

$$R_{sys,min} = \frac{Q_{min}}{t_D}$$

where:

$R_{sys,min}$ = minimum total system discharge rate (m^3/min)
Q_{min} = minimum volume of inert gas agent (m^3)
t_D = maximum time to discharge Q_{min} (min)

8.4.2.1* The maximum time, t_D, to discharge the minimum volume of inert gas agent shall not exceed 3 minutes, unless a longer time is established by test for a specific hazard.

8.4.2.2 Where multiple hazard classifications exist in the protected enclosure, the shortest time to discharge, t_D, shall be used.

8.4.3* The number of hybrid nozzles shall be determined in accordance with the following equation:

[8.4.3]

$$N = \frac{R_{sys,min}}{R_{D,IG}}$$

where:

N = minimum number of hybrid nozzles (nozzles)
$R_{sys,min}$ = minimum system inert gas agent discharge rate (m^3/min)
$R_{D,IG}$ = inert gas agent discharge rate of the hybrid nozzle (m^3/min/nozzle)

8.4.3.1 The calculated number of hybrid nozzles shall be rounded up to a whole number.

8.4.3.2 The spacing of hybrid nozzles shall not exceed the manufacturer's specifications.

8.4.4 The supplied quantity of inert gas agent, Q_{supply}, shall be not less than the minimum, as determined in 8.4.1.

8.4.5 The supplied quantity of water shall be calculated from the following equation:

[8.4.5]

$$W = F_{S,H_2O} \cdot \left(V_{pipe} + N \cdot R_{D,H_2O} \cdot t\right)$$

where:

W = quantity of water (L)
F_{S,H_2O} = water safety factor
V_{pipe} = internal volume of the water-filled pipe (L)
N = minimum number of hybrid nozzles (nozzles)
R_{D,H_2O} = water discharge rate of the hybrid nozzle (L/min/nozzle)
t = design discharge duration (min)

8.4.5.1 The water safety factor, F_{S,H_2O}, shall be 1.2.

8.4.5.2 The design discharge duration, t, shall be determined from the supplied quantity of inert gas agent, Q_{supply}, and the actual system discharge rate.

8.4.6 The supplied quantity of hybrid media shall be increased through the use of additional design factors to compensate for any special conditions that would affect the extinguishing efficiency.

8.5 Concentration of Oxygen.

8.5.1 The resultant concentration of oxygen shall be calculated using the following equation:

[8.5.1]

$$C_{oxygen,red} = 20.95e^{-\left[\frac{(273+T_{max})\cdot Q_{supply}}{294.4\cdot F_{atm}\cdot V_{enc}}\right]}$$

where:

$C_{oxygen,red}$ = concentration of oxygen after discharge (%vol/vol)
T_{max} = maximum expected ambient enclosure temperature (°C)
Q_{supply} = discharged volume of inert gas agent (m^3)
F_{atm} = atmospheric correction factor *(See 8.4.1.3.)*
V_{enc} = volume of the enclosure (m^3)

8.5.2 The concentration of oxygen after discharge shall not be less than the thresholds specified in Section 4.3.

8.6 Hybrid Media Retention for Prevention of Re-ignition.

8.6.1* For fires involving Class A combustibles subject to deep-seated burning, an extinguishing atmosphere shall be maintained throughout the hazard zone for a time period sufficient to allow for response by personnel trained and equipped to extinguish the fire.

8.6.2 For hazards where there are objects that might be heated above ignition temperature of the fuel or where the ignition temperature of a flammable liquid fuel is below the boiling point of the fuel, the hybrid media concentration shall be maintained for a sufficient time to allow cooling below the fuel's ignition temperature or for response by personnel.

8.7 Hybrid Nozzle Selection, Quantity, and Location.

8.7.1 Hybrid nozzles shall be selected, located, and oriented in accordance with the criteria determined in accordance with 8.3.1.

8.7.2 Discharge of inert gas agent and water shall be established at every hybrid nozzle in 30 seconds or less from the time of system activation, unless a longer delivery time is permitted by the authority having jurisdiction.

8.7.3 Nozzles shall be placed such that their discharge will not splash flammable liquids or create dust clouds that could extend the fire, create an explosion, or otherwise adversely affect the contents or the integrity of the enclosure.

Chapter 9 Design Requirements for Local Application Systems

9.1 General.

9.1.1 Description. A local application system shall consist of a fixed supply of hybrid media permanently connected to a fixed pipe network with fixed nozzles arranged to discharge the hybrid media on or around the hazard or object to be protected.

9.1.2 Uses. A local application system shall be used to protect an object or a hazard in an unenclosed or partially enclosed condition.

9.1.3 General Requirements. Local application systems shall be designed, installed, tested, and maintained in accordance with the applicable requirements in Chapter 4 and with the additional requirements set forth in Chapter 13.

9.1.4 Application Characteristics. The characteristics of the local application shall be consistent with the listing of the system or approved by the authority having jurisdiction.

9.1.5 Safety Requirements. The safety requirements of Section 4.2 shall apply where locally high concentrations of the inert gas will be developed.

9.2 Hazard Specifications.

9.2.1 Extent of Hazard.

9.2.1.1 The entire hazard shall be protected.

9.2.1.2 The hazard shall include combustible objects, hazards which could cause spray fires, or all areas that are or can become coated by combustible liquids or shallow solid coatings, such as areas subject to spillage, leakage, dripping, splashing, or condensation.

9.2.1.3 The hazard shall also include all associated materials or equipment, such as freshly coated stock, drain boards, hoods, ducts, and so forth, which could extend fire outside or lead fire into the protected area.

9.2.1.4 The hazard shall be so isolated from other hazards or combustibles that fire will not spread outside the protected area.

9.2.1.5 Curbing or dikes to isolate flammable liquid spills shall be required to limit the spread of spills to the area protected by the hybrid local application system.

9.2.1.6 Adjacent or interconnected hazards shall be permitted to be subdivided into smaller groups or sections with the approval of the authority having jurisdiction.

9.2.1.7 Systems for the protection of hazards that are subdivided in accordance with 9.2.1.6 shall be designed to give immediate independent protection to adjacent groups or sections.

9.2.2 Location of Hazard.

9.2.2.1 The hazard shall be indoors.

9.2.2.2 The hybrid system shall be designed to account for air movement and the ambient temperature range of the protected hazard.

9.2.3 Flammable Liquid Hazards. Where flammable liquids with depth greater than 6 mm (¼ in.) are to be protected, a minimum freeboard of 30 mm (1.2 in.) shall be provided, unless otherwise noted in the nozzle listing or as approved by the authority having jurisdiction.

9.3 Nozzle Selection, Quantity, and Location.

9.3.1 The basis for nozzle selection shall be performance data that clearly depict the interrelationship of agent quantity, discharge rate, discharge time, area coverage, orientation, and the horizontal and vertical distance of the nozzle from the protected surface.

9.3.2* The performance data required by 9.3.1 shall be determined by fire testing that is representative of the configuration and conditions of the hazard being protected.

9.3.3 The number of nozzles required to cover the entire hazard area shall be based on the area coverage of each nozzle.

9.3.4 Local application nozzles shall be located in accordance with spacing and discharge rate limitations stated in nozzle listings or approved by the authority having jurisdiction.

9.3.5 Nozzles shall be located so as to protect coated stock or other hazards extending above a protected surface.

9.4 Discharge Rate.

9.4.1 The design discharge rate through individual nozzles shall be determined on the basis of location or projection distance in accordance with specific listings or be approved by the authority having jurisdiction.

9.4.2 The system discharge rate shall be the sum of the individual rates of all the nozzles and discharge devices used in the system.

9.5 Discharge Time.

9.5.1 The design discharge time shall be not less than the greater of the following:

(1) 120 seconds
(2) Twice the extinguishment time as determined in accordance with Section 9.3

9.5.2* The discharge time shall be increased to compensate for any hazard condition that would require a longer cooling period or for mechanical rundown time to prevent re-ignition.

9.5.3 Where there is a possibility that metal or other material can become heated above the ignition temperature of the fuel, the discharge time shall be increased to allow adequate cooling time.

9.5.4* Where the fuel has an autoignition point below its boiling point, such as paraffin wax and cooking oils, the discharge time shall be increased to permit cooling of the fuel to prevent re-ignition.

9.6 Hybrid Media Quantity. The quantity of hybrid media required for local application systems shall be based on the rate of discharge and the time that the discharge must be maintained to ensure complete extinguishment.

Chapter 10 Design Requirements for Marine Systems (Reserved)

Chapter 11 System Documentation

11.1 System Working Plans.

11.1.1 Submittal of Working Plans. Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed.

11.1.2 Deviations from Approved Plans. Deviation from approved plans shall be approved by the authority having jurisdiction.

11.1.3 Qualifications. The working plans shall be prepared by, or under the supervision of, an individual that is trained and certified by the system manufacturer.

11.1.4 Component Identification. Special symbols shall be defined and used to clearly identify the components of the hybrid system.

11.1.5 Required Information. The working plans shall provide the following information as pertaining to the design of the system:

(1) Plan identification number or project number
(2) Name and address of plans preparer and installing contractor
(3) Hybrid extinguishing system manufacturer and system designation
(4) Date of preparation and subsequent revisions
(5) Name of owner and occupant
(6) Property location, including street address and site elevation relative to sea level
(7) Point of compass, drawing scale, and symbol legend
(8) Plan view of the protected enclosure or equipment
(9) Location and dimensions of obstructions that affect the system layout
(10) Location of fire walls that affect the system layout
(11) Enclosure cross section, with full height or schematic diagram, including location and construction of building floor/ceiling assemblies above and below, raised access floor, and suspended ceiling
(12) Description of occupancies and hazards (fuels) being protected
(13) Enclosure occupancy status (normally occupied, occupiable, or unoccupiable)
(14) Inert gas agent used in the hybrid media
(15)* Description of the critical system application criteria
(16) Maximum and minimum expected ambient temperatures of the protected space and the agent storage container location(s)
(17) Location and description of the water and inert gas agent supplies, including container quantity, capacity, weight, pressure, or other characteristics, as applicable
(18) Identification of nozzles, including size and orifice or part number, as appropriate
(19) Identification of pipe and fittings, including material specifications, grade, and pressure rating
(20) Description of wire or cable
(21) Equipment schedule or bill of materials for each piece of equipment or device, indicating the device name, manufacturer, model or part number, quantity, and description
(22) Plan view of the protected area, showing enclosure partitions (full and partial height); piping layout, including identification of pipe type, contents, and size; nozzles; pipe hangers and rigid pipe supports; seismic bracing, if required; system actuation and control equipment; and signage
(23) Plan view of the protected area, in accordance with *NFPA 70* and *NFPA 72*, showing detection, alarm, and control system, including all devices; end-of-line device locations; location of controlled/interlocked devices, such as dampers/shutters, power supply equipment, fuel supplies, and air handling equipment
(24) Isometric view of the hybrid distribution system, showing detailed descriptions of each pipe segment; pipe fitting, including reducers and strainers; control or selector valve; drain valve; and nozzle
(25) Seismic separations and expansion joints, if any
(26) Calculation of seismic loads, if seismic restraint is required
(27) Details of hangers, rigid pipe supports, and bracing
(28) Details of container mounting, including method of securing to building structure
(29) System sequence of operations, including a complete step-by-step description of the functioning of abort and maintenance switches, delay timers, and any interlocks with HVAC equipment, dampers, production equipment, fuel shutoffs, electric shut-downs, and door closers
(30) Riser diagram of the system control panel
(31) Hydraulic and pneumatic calculations to determine flow rates, nozzle pressures, and maximum predicted pressure for each pipe network
(32) Calculations to determine the quantity of water, quantity of inert gas agent, and discharge time
(33) Calculations to determine the size of backup batteries *(See NFPA 72 for documentation requirements.)*
(34) Details of any special features

11.1.6 As-Built Plans. If the final installation varies from the approved working plans, new working plans, representing the as-built installation, shall be prepared.

11.2 System Flow Documentation.

11.2.1 Pre-Engineered Systems. System flow calculations shall not be required for pre-engineered systems.

11.2.2 Engineered Systems.

11.2.2.1 Pneumatic calculations for the inert gas agent portion of the system shall be prepared on form sheets that include a summary and detailed work sheets.

11.2.2.2 Hydraulic calculations for the water portion of the system shall be prepared on form sheets that include a summary and detailed work sheets.

11.2.2.3 Where flow calculation software is used, flow calculation details shall include the version of the flow calculation program.

11.2.3 Summary Sheets. The calculation summary sheet shall contain the following information:

(1) Name and address of plans preparer and installing contractor
(2) Hybrid extinguishing system manufacturer and system designation
(3) Date of preparation

(4) Name of owner and occupant
(5) Property location, including street address and site elevation relative to sea level
(6) Description of occupancies and hazards (fuels) being protected
(7) Type of application, total flooding or local application
(8) System design requirements, including the following:
    (a) Total flooding, design volume of space protected
    (b) Local application area of water application
    (c) Total gas requirement
    (d) Total water requirement

11.2.4 Detailed Work Sheets. The calculation detailed work sheets shall contain the following information:

(1) Sheet number
(2) Nozzle description
(3) Pipe size
(4) Pipe lengths, center to center of fittings
(5) Equivalent pipe lengths for fittings and devices
(6) Calculated nozzle pressure
(7) Maximum calculated pressure in the pipe network
(8) Calculated flow rates:
    (a) Inert gas flow: slpm (scfm)
    (b) Water flow: lpm (gpm)
(9) Calculated discharge time

11.3 Detection, Actuation, and Control Systems Documentation. Documentation for detection, actuation, and control systems shall meet the requirements of *NFPA 72*.

11.4* Owner's Documentation.

11.4.1 A copy of the manufacturer's design, installation, operation, and maintenance manual(s) shall be provided to the owner.

11.4.2 A copy of the as-built plans shall be provided to the owner.

11.4.3 An as-built instruction and maintenance manual that includes a full sequence of operations and a full set of drawings and calculations shall be maintained or be accessible on site.

11.5 System Information Sign.

11.5.1* The installing contractor shall provide a permanently marked system information sign.

11.5.2 The sign shall be placed within 1.5 m (5 ft) of the storage cylinders or releasing control panel.

11.5.3 The sign shall include the following information, as applicable:

(1) Location of the protected area or areas
(2) Description of the hazard protected
(3) Design type application
(4) System manufacturer and system designation
(5) Volume or area protected, depending on application
(6) Total number of nozzles protecting the hazard
(7) Design application density
(8) Design flow rate and duration
(9) Total inert gas agent and water requirements, as calculated
(10) Description of any compartment or enclosure characteristics that are essential to system performance
(11) Name of installing contractor and contact information
(12) Date of installation
(13) Plan identification number or project number of the submitted as-built plans

Chapter 12 Installation Requirements

12.1 General.

12.1.1 Listed materials and devices shall be installed in accordance with their listing.

12.1.2 Materials and devices shall be installed in accordance with the manufacturer's instructions.

12.1.3 System components shall be located, installed, or protected so they are not subject to mechanical, corrosive (chemical, etc.), or other damage that could impair operation.

12.1.4 Working Plans.

12.1.4.1 The system shall be installed in accordance with the approved working plans.

12.1.4.2 Deviations from the approved working plans shall be approved.

12.1.5 Qualifications. Hybrid systems shall be installed by personnel that are qualified in accordance with Section 4.4.

12.2 Nozzles. Nozzles shall be installed in accordance with the manufacturer's instructions, including, but not limited to, the following installation criteria:

(1) Minimum and maximum height above the floor
(2) Minimum and maximum distances between nozzles
(3) Minimum and maximum distance from nozzles to walls or partitions
(4) Location of nozzles with respect to continuous or discontinuous obstructions
(5) Clearance between the nozzle and the ceiling
(6) Permitted nozzle orientation

12.3 Hazardous Locations. Components of the electrical portions of hybrid systems that are installed in classified locations as defined in Article 500 of *NFPA 70* shall be listed for such use.

12.4 Electrical Clearances. All system components shall be located so as to maintain minimum electrical clearances from live parts in accordance with Subpart S of 29 CFR 1910.

12.5 Pipe Network.

12.5.1 Pipe Identification

12.5.1.1 All pipe, including specially listed pipe, shall be marked along its length by the manufacturer in such a way as to identify the type of pipe.

12.5.1.2 Pipe identification shall include the manufacturer's name, model designation, and/or schedule.

12.5.1.3 Pipe or tubing marking shall not be painted, concealed, or removed prior to approval by the authority having jurisdiction.

12.5.1.4 Welding shall be performed in accordance with Section IX, "Welding, Brazing, and Fusing Qualifications," of the ASME *Boiler and Pressure Vessel Code*.

12.5.2* Pipe shall be cleaned internally and be free of foreign material before nozzles are installed.

12.5.3* If used, pipe joint compound, tape, or lubricant shall be applied only to the male threads of the joint with the exception of the first thread.

12.5.4 Installation Standards.

12.5.4.1 Where the maximum system operating pressure does not exceed 12.1 bar (175 psi), piping and tubing shall be installed in accordance with NFPA 13.

12.5.4.2 Where the maximum system operating pressure exceeds 12.1 bar (175 psi), piping and tubing shall be installed in accordance with ASME B31.1.

12.5.5 Pressure Rating. All system piping, tubing, and hose shall be rated for the maximum working pressure to which they are exposed.

12.5.6 Flexible Components. Any flexible piping, tubing, hose, or combination thereof shall be constructed and installed in accordance with the manufacturer's instructions.

12.5.7* Tube Bending.

12.5.7.1 Bending of Type K and Type L copper tube or stainless steel tube shall be permitted, provided that all bending details are in accordance with the tubing manufacturer's recommendations, the strength requirements of ASME B31.1, or the following, whichever is greatest:

(1) For Type K or Type L copper tubing, the minimum bending radius is six pipe or tube diameters.
(2) For Type 304L or Type 316 stainless steel tube, the minimum bending radius is two diameters up to 38 mm (1½ in.) OD and four diameters for 51 mm (2 in.) tubing.

12.5.7.2 Bending tools shall be used for all bending in accordance with the following:

(1) Power bending tools with the correct radius dies shall be required for tube larger than 20 mm (¾ in.).
(2) Hand or bench dies with the correct radius dies shall be permitted to be used to bend tubing 20 mm (¾ in.) and smaller.
(3) Flattened bends where the larger diameter is greater than 1.08 times the least diameter shall not be permitted.

12.5.8* Pipe Hangers and Supports. Pipe hangers and supports shall be designed and installed in accordance with recognized industry practices and manufacturer's instructions.

12.5.8.1 All pipe hangers and supports shall be attached directly to a rigid fixed structure.

12.5.8.2 All hangers and components shall be steel.

12.5.8.3 Ordinary cast-iron hangers/supports, conduit clamps, or "C" clamps shall not be used.

12.5.8.4 All pipe supports shall be designed and installed to prevent lateral movement of supported pipe during system discharge while permitting longitudinal movement to accommodate expansion and contraction caused by temperature changes.

12.5.8.4.1* Rigid hangers shall be installed wherever a change in elevation or direction occurs.

12.5.8.4.2 Nozzles shall be supported so as to prevent movement of the nozzle during discharge.

12.5.8.5 Where seismic bracing is required, bracing shall be in accordance with local codes and the authority having jurisdiction.

12.5.9 System Drainage. All system piping and fittings shall be installed so that the entire system can be drained.

12.5.10 Piping Slope Requirements. The wetted discharge piping shall be installed with a slope of at least 2 mm/m (¼ in. per 10 ft) of run toward the low point drain.

12.6 Gas and Water Storage Containers.

12.6.1 Accessibility.

12.6.1.1 Storage containers and accessories shall be installed so that inspection, testing, recharging, and other maintenance are facilitated.

12.6.1.2 A clear space, at least 1 m (3 ft) in front of the containers, shall be marked to maintain access for maintenance.

12.6.2 Storage Temperatures.

12.6.2.1 Storage temperatures shall be maintained within the range specified in the manufacturer's listing.

12.6.2.2 External heating or cooling shall be an approved method to keep the temperature of the storage container within desired ranges.

12.6.3 Container Securement. Containers shall be secured to prevent container movement and possible physical damage.

12.6.4* Strainers and Filters. A strainer or filter shall be installed at each water supply connection.

12.7 Valves and Pressure Gauges.

12.7.1 Valves and pressure gauges shall be installed such that they are accessible for operation, inspection, and maintenance.

12.7.2 Valves shall be installed with clearance to ensure operation of the valve from the fully closed to fully open position.

12.7.3 All control, drain, and test connection valves shall be provided with permanently marked, weatherproof, metal or rigid-plastic, identification signs, secured by corrosion-resistant wire or chain or by other approved means.

12.7.4 Valve Supervision. All valves controlling the supply of water, inert gas agent, or hybrid media to hybrid nozzles shall be installed to accommodate the means of supervision, as specified in the working plans.

12.7.5 Relief Valves. Relief valve discharge piping shall be routed in accordance with the working plans.

12.7.6 Check Valves. Check valves shall be installed in the direction of flow.

12.8 Electrical Equipment and Systems.

12.8.1 Electrical equipment associated with hybrid systems shall be installed in accordance with the requirements of *NFPA 70*.

12.8.2 All signaling system circuits and wiring shall be installed in accordance with *NFPA 72*.

12.8.3 All signaling line circuits and wiring shall be installed in accordance with *NFPA 72*.

12.8.4 All initiating and releasing circuit wiring shall be installed in conduit or closed raceway.

12.9 System Review and Testing. The completed system shall be reviewed and tested by personnel qualified in accordance with Section 4.4 to determine that the system has been properly installed and will function as specified.

12.9.1 Only listed or approved equipment and devices shall be used in the system.

12.9.2 Review of Installation.

12.9.2.1 It shall be determined that the protected enclosure is in general conformance with the construction documents.

12.9.2.2 All operating devices shall be checked for proper operation following directions to be given in the manufacturer's installation operation and maintenance manual.

12.9.2.3 Proper operation of auxiliary devices such as pressure switches, flow alarms, and pressure trips shall be verified.

12.9.2.4 Proper operation of all alarms and indicators shall be verified.

12.9.2.5 Proper operation of the fire alarm control panel and all connected devices such as detectors, manual stations, time delays, alarms, remote annunciators and releasing devices shall be verified.

12.9.2.6* Sensors providing feedback for system operation shall be verified for proper connection to the system in accordance with the manufacturer's instructions.

12.9.2.7 All filters and strainers shall be inspected and cleaned or replaced as necessary.

12.9.3 Pressure Test of Pipe.

12.9.3.1 The pipe system shall be pressure tested in a closed circuit using nitrogen or other dry gas.

12.9.3.2* The pipe shall be pressurized to the normal system operating pressure for that pipe.

12.9.3.3 After removing the source of pressurizing gas, the pressure in the pipe shall be not less than 90 percent of the test pressure after 10 minutes.

12.9.4 Test Report.

12.9.4.1 The system review and testing shall be documented in a report.

12.9.4.2 The report shall be maintained by the system owner for the life of the system.

Chapter 13 Acceptance Testing

13.1 Approval of Installations.

13.1.1* An acceptance test plan shall be approved prior to scheduling of acceptance testing.

13.1.2 A complete step-by-step description of the proposed acceptance test procedure, identifying all devices controls and functions to be tested and how the test will be conducted, shall be approved prior to scheduling of acceptance testing.

13.1.3* Where a hybrid fire-extinguishing system operates in conjunction with other building systems, functions, or components, the final testing shall be conducted with those systems as appropriate.

13.1.4 The completed system shall be reviewed and tested by qualified personnel to meet the approval of the authority having jurisdiction.

13.1.5 The completed system shall be reviewed to confirm that only listed or approved equipment and devices have been used.

13.1.6 The installing contractor shall take the following actions:

(1) Notify the authority having jurisdiction and the owner's representative of the time and date testing is to be performed.
(2) Perform all required acceptance tests.
(3) Confirm in writing the status of all system components and controls.
(4) When the system has not been left in service, confirm in writing those responsible for placing the system in service.

13.1.7 The acceptance testing shall be documented in a test report.

13.1.8 The acceptance test report shall be maintained by the system owner for the life of the system.

13.2 Acceptance Requirements.

13.2.1 Review of Mechanical Components.

13.2.1.1 It shall be determined that the protected enclosure is in general conformance with the construction documents.

13.2.1.2 The piping system shall be inspected to determine that it is in compliance with the design and installation documents and hydraulic calculations.

13.2.1.3 Nozzles and pipe size shall be in accordance with the approved working plans.

13.2.1.4 The means of pipe size reduction and the attitudes of tees shall be checked for conformance to the design for proper orientation.

13.2.1.5 Piping joints, discharge nozzles, and piping supports shall be restrained to prevent unacceptable vertical or lateral movement during discharge.

13.2.1.6 Discharge nozzles shall be installed in such a manner that piping cannot become detached during discharge.

13.2.1.7 The discharge nozzles, piping, and mounting brackets shall be installed in such a manner that they do not cause injury to personnel.

13.2.1.8 All water and gas storage containers shall be located in accordance with an approved set of system drawings.

13.2.1.9 All containers and mounting brackets shall be fastened in accordance with the manufacturer's requirements.

13.2.1.10 All filters and strainers shall be inspected for proper location and relocated as necessary.

13.2.1.11 Discharge nozzles shall be inspected for minimum clearances to obstructions per the manufacturer's requirements.

13.2.2 Review of Electrical Components.

13.2.2.1 All wiring systems shall be checked for proper installation in conduit and in compliance with the approved drawings.

13.2.2.2 It shall be confirmed that ac wiring and dc wiring are not combined in a common conduit or raceway unless properly shielded and grounded.

13.2.2.3* All wiring systems shall be checked for grounding and shielding in accordance with the working plans.

13.2.2.4* All field circuits shall be confirmed to be free of ground faults and short circuits.

13.2.2.5 It shall be verified that the hybrid system branch piping has not been used as an electrical ground.

13.2.2.6 The detection devices shall be checked for proper type and location as specified on the system drawings.

13.2.2.7 Manual pull stations shall be confirmed as accessible, accurately identified, and properly protected to prevent damage.

13.2.2.8 Abort Switches. Where abort switches are allowed by the authority having jurisdiction, verify the following:

(1) Switches do not remain in the abort position when released.
(2) Manual controls override the abort function.

13.2.2.9 Enclosure Integrity. For total flooding systems, the enclosure shall be examined to verify that the number and size of unclosable openings are in accordance with working plans.

13.2.3 Functional Tests. If the system is connected to an alarm receiving office, the alarm receiving office shall be notified that the fire system test is to be conducted and that an emergency response by the fire department is not desired.

13.2.3.1 All operating devices shall be checked for proper operation following directions and procedures given in the manufacturer's installation operation and maintenance manual.

13.2.3.2 Proper operation of auxiliary devices such as pressure switches, flow alarms, and pressure trips shall be verified.

13.2.3.3 Proper operation of all alarms and indicators shall be verified.

13.2.3.4 Proper operation of the fire alarm control panel and all connected devices such as detectors, manual stations, time delays, alarms, remote annunciators, and releasing devices shall be verified.

13.2.3.5 Where practicable, the maximum number of systems that are expected to operate in case of fire shall be in full operation simultaneously when the adequacy and condition of the water supply are checked.

13.2.4 Flow Tests.

13.2.4.1 Except as permitted in 13.2.4.1.2, a flow test shall be conducted.

13.2.4.1.1* The discharge from all nozzles shall be observed to ensure the following:

(1) Nozzle orifices are not clogged.
(2) Nozzles are correctly positioned.

13.2.4.1.2* Where acceptable to the authority having jurisdiction, an alternative test method that does not require inert gas or water to be discharged shall be permitted to confirm that each nozzle discharges water and inert gas.

13.2.4.2 For systems protecting Class A fuels subject to deep-seated burning, a full discharge test shall be conducted to verify that the design concentration of hybrid media is achieved and maintained for the required retention time.

13.2.4.3 Where a full discharge test is conducted, measurement of the resultant oxygen concentration shall be permitted as a means of determining the hybrid media concentration.

13.2.4.4 Subsequent to a flow or discharge test, all filters and strainers shall be inspected and cleaned or replaced as necessary.

13.3 System Design Information Sign. The accepting authority shall confirm that the system design information sign has been provided and that it accurately reflects the system design parameters.

13.4 Owner's Documentation. Documentation shall be provided to the owner in accordance with Section 11.4.

Chapter 14 Inspection, Testing, and Maintenance

14.1 General.

14.1.1* The property owner or designated representative shall be responsible for properly maintaining a fire protection system.

14.1.2 Inspection, testing, maintenance, and impairment procedures shall be implemented in accordance with those established in this document and in accordance with the manufacturer's instructions.

14.1.3 Personnel performing inspection, testing, or maintenance shall be qualified in accordance with Section 4.4.

14.1.4 The date the inspection is performed and the initials of the person performing the inspection shall be recorded.

14.1.5 Personnel making inspections shall keep records for those extinguishing systems that were found to require corrective actions.

14.1.6 A completed copy of the inspection report shall be furnished to the owner of the system or an authorized representative.

14.1.7 Inspection, testing, and maintenance records shall be retained by the owner for the life of the system.

14.1.8* Those charged with maintenance of the system or using maintenance for corrective actions shall be trained in the maintenance of the specific make and model system.

14.1.9 Maintenance personnel shall review all manufacturer's service bulletins pertaining to the system.

14.1.10 The inspection, testing and maintenance records shall be retained for a period of 1 year after the next inspection, test, or maintenance of that type required by the standard.

14.1.11 The inspection, testing, and maintenance records shall be permitted to be furnished, accessed, and stored electronically.

14.2 Periodic Inspection and Maintenance.

14.2.1 A manufacturer's test and maintenance procedure shall be provided to the owner.

14.2.2* Weekly Inspection.

14.2.2.1 At least weekly, the following shall be inspected:

(1) Inert gas and water supply lines are intact.
(2) Nozzles are not obstructed.
(3) Protective caps if supplied are in place on every nozzle.
(4) Fire alarm control panel is in "normal" ready condition.
(5) System isolation valves are locked in full open position.
(6) Tamper seals are in place.

14.2.2.2 Any deficiencies shall be corrected.

14.2.3 Semiannual Inspection.

14.2.3.1 The following tasks, in addition to the weekly inspection tasks, shall be performed at least semiannually:

(1) Check inert gas supply tanks for proper pressure corrected for ambient temperature. If any tank shows a pressure loss of more than 10 percent corrected for temperature, check for the root cause and repair or replace the tank as necessary to provide the required quantity of inert gas in storage.
(2) Check the water level in the storage tank (if applicable). If the water level is more than 5 percent below design level, check for the root cause and repair or replace the tank as necessary to provide the required quantity of water in storage.

14.2.3.2 Any deficiencies shall be promptly corrected.

14.2.3.3 The results of an inspection shall be recorded on both of the following:

(1) A record tag secured to each cylinder
(2) An inspection report that addresses, at a minimum, all of the points of inspection outlined in 14.2.2.1 or 14.2.3.1, as applicable

14.2.4 Annual Maintenance.

14.2.4.1 The following shall be performed by competent personnel *(see 14.2.4.2)* at least annually using available documentation required in Chapter 11:

(1) Perform a functional test of the system (discharge of hybrid media is not required).
(2) Check hybrid media containers for signs of damage. *(See Section 14.4.)*
(3) Cycle all system valves (discharge of hybrid media is not required).
(4) Clean or replace strainers and filters per system manufacturer's instructions.
(5) Check that there have been no changes to the size, type, and configuration of the hazard and system.
(6) Check and test all time delays for operation.
(7) Check and test all audible notification appliances for operation.
(8) Check and test all visual notification appliances for operation.
(9) Check that all warning signs are installed and visible.
(10) Check operation of all manual release devices.
(11) Check and test each automatic detector using methods specified in *NFPA 72*.
(12) Check and verify functional operation of system interlocks.

14.2.4.2* Those charged with maintenance of the system shall be trained in the maintenance of the specific make and model system.

14.2.4.3 Maintenance personnel shall review all manufacturer's service bulletins pertaining to the system.

14.2.4.4 Annual maintenance results shall be recorded in an inspection report that addresses, at a minimum, the requirements of 14.2.4.

14.3 Hose Test.

14.3.1 All system hose shall be examined annually for damage.

14.3.2 All hoses used to distribute hybrid media or its constituents during discharge shall be hydrostatically tested or replaced every 5 years or whenever visual examination shows any deficiency, whichever occurs first.

14.3.3 The test pressure shall be equal to 1½ times the maximum system operating pressure.

14.3.4 The testing procedure shall be as follows:

(1) The hose is removed from any attachment.
(2) The hose assembly is then placed in a protective enclosure designed to permit visual observation of the test.
(3) The hose must be completely filled with water before testing.
(4) Pressure then is applied at a rate-of-pressure rise to reach the test pressure within 1 minute. The test pressure is then maintained for 1 full minute. Observations are then made to note any distortion or leakage.
(5) After observing the hose for leakage, movement of couplings, and distortion, the pressure is released.

14.3.5 The hose assembly shall be considered to pass if all of the following criteria are met:

(1) No loss of pressure during the test
(2) No movement of the couplings while under pressure
(3) No permanent distortion of the hose

14.3.6 Each hose assembly that passes the hydrostatic test shall be marked with the date of the test.

14.3.7* Each hose assembly that passed the test shall be dried internally before being reinstalled.

14.3.8 Each hose assembly that fails the hydrostatic test shall be marked and destroyed.

14.4* Inert Gas Agent Container Test. Inert gas storage containers shall be periodically inspected and tested in accordance with this section.

CAUTION

Inert gas agent containers are under high pressure. Observe safety precautions when handling cylinders, including installation of anti-recoil devices on cylinder outlets immediately upon disconnecting the cylinder outlet from the system pipe and before removing the cylinder from its bracket.

14.4.1 Inert gas agent containers built in accordance with U.S. Department of Transportation (DOT), Transport Canada (TC), or similar regulatory bodies shall be periodically requalified in accordance with the provisions of the governing regulatory body.

14.4.2 Inert gas agent containers continuously in service without discharging shall be given a complete external visual inspection every 5 years or more frequently if required.

14.4.2.1 The visual inspection shall be in accordance with Section 3 of CGA C-6, except that inert gas agent containers need not be emptied and shall not be stamped while under pressure.

14.4.2.2 The results of the visual inspection shall be recorded on both of the following:

(1) A record tag attached to each cylinder
(2) A suitable inspection report

14.4.2.3 A completed copy of the inspection report shall be furnished to the owner of the system or an authorized representative.

14.4.2.4 Container inspection records shall be retained by the owner for the life of the system.

14.4.2.5 When an external visual inspection indicates that the container has been damaged, the container shall be requalified in accordance with the requirements of the applicable regulatory body.

14.5 Water Storage Container Inspection and Test.

14.5.1 Water storage containers shall be subjected to an annual external visual inspection.

14.5.2 Water storage containers shall be drained and subjected to an internal inspection in accordance with 14.5.2.1 or 14.5.2.2.

14.5.2.1 Water storage containers constructed of corrosion-resistant material shall be inspected every 5 years.

14.5.2.2 Water storage containers that have an internal corrosion-resistant coating shall be inspected annually.

14.5.3 Water storage containers built in accordance with U.S. Department of Transportation (DOT), Transport Canada (TC), or similar regulatory bodies shall be periodically requalified in accordance with the provisions of the governing regulatory body.

14.5.4 The results of the visual inspection shall be recorded on both of the following:

(1) A record tag attached to each cylinder
(2) A suitable inspection report

14.5.5 A completed copy of the inspection report shall be furnished to the owner of the system or an authorized representative.

14.5.6 Container inspection records shall be retained by the owner for the life of the system.

14.6 Actuation/Impairment.

14.6.1 Actuation, impairment, and restoration of the system shall be reported promptly to the authority having jurisdiction.

14.6.2 Following actuation, the system shall be returned to service by personnel who are specifically trained and qualified to maintain the system.

14.7 Training.

14.7.1 All persons that will be expected to inspect or operate fire-extinguishing systems shall be trained and kept trained in the functions they are expected to perform.

14.7.2* Personnel working in an enclosure protected by a hybrid system shall receive training regarding system operating procedures and safety issues.

14.7.3 Training for personnel working in the protected space shall be refreshed periodically on a schedule determined by the system owner but not less frequently than every 12 months.

14.7.4 The system owner shall maintain a record of the most recent training for each person.

14.8* Corrections and Repairs.

14.8.1* The property owner or designated representative shall correct or repair deficiencies or impairments.

14.8.1.1 Where any deficiency is noted, the appropriate corrective action shall be taken.

14.8.1.2 Where an impairment to protection occurs, the procedures outlined in Chapter 15 shall be followed.

14.8.2 Corrections and repairs shall be performed by personnel qualified as required by Section 4.4.

Chapter 15 Impairment

15.1* General.

15.1.1 Minimum Requirements.

15.1.1.1 This chapter shall provide the minimum requirements for a fire protection system impairment program.

15.1.1.2 Measures shall be taken during the impairment to ensure that increased risks are minimized and the duration of the impairment is limited. [**25:**15.1.1.2]

15.2 Impairment Coordinator.

15.2.1 The property owner or designated representative shall assign an impairment coordinator to comply with the requirements of this chapter. [**25:**15.2.1]

15.2.2 In the absence of a specific designee, the property owner or designated representative shall be considered the impairment coordinator. [**25:**15.2.2]

15.2.3 Where the lease, written use agreement, or management contract specifically grants the authority for inspection, testing, and maintenance of the fire protection system(s) to the tenant, management firm, or managing individual, the tenant, management firm, or managing individual shall assign a person as impairment coordinator. [**25:**15.2.3]

15.3 Tag Impairment System.

15.3.1* A tag shall be used to indicate that a system, or part thereof, has been removed from service. [**25:**15.3.1]

15.3.2* The tag shall be posted at each fire department connection and the system control valve, and other locations required by the authority having jurisdiction, indicating which system, or part thereof, has been removed from service. [**25:**15.3.2]

15.4 Impaired Equipment.

15.4.1 The impaired equipment shall be considered to be the fire protection system, or part thereof, that is removed from service.

15.4.2 The impaired equipment shall include hybrid (water and inert gas) systems.

15.5* Preplanned Impairment Programs.

15.5.1 All preplanned impairments shall be authorized by the impairment coordinator. [**25:**15.5.1]

15.5.2 Before authorization is given, the impairment coordinator shall be responsible for verifying that the following procedures have been implemented:

(1) The extent and expected duration of the impairment have been determined.
(2) The areas or buildings involved have been inspected and the increased risks determined.
(3) Recommendations to mitigate any increased risks have been submitted to management or the property owner or designated representative.
(4) Where a fire protection system is out of service for more than 10 hours in a 24-hour period, the impairment coordinator shall arrange for one of the following:
   (a) Evacuation of the building or portion of the building affected by the system out of service
   (b)* An approved fire watch
   (c)* Establishment of a temporary water supply
   (d)* Establishment and implementation of an approved program to eliminate potential ignition sources and limit the amount of fuel available to the fire
(5) The fire department has been notified.
(6) The insurance carrier, the alarm company, property owner or designated representative, and other authorities having jurisdiction have been notified.
(7) The supervisors in the areas to be affected have been notified.
(8) A tag impairment system has been implemented. *(See Section 15.3.)*
(9) All necessary tools and materials have been assembled on the impairment site.

[**25:**15.5.2]

15.6* Emergency Impairments.

15.6.1 Emergency impairments shall include, but are not limited to, interruption of water supply, frozen or ruptured piping, and equipment failure, and includes impairments found during inspection, testing, or maintenance activities. [**25:**15.6.1]

15.6.2* The coordinator shall implement the steps outlined in Section 15.5. [**25:**15.6.2]

15.7* Restoring Systems to Service. When all impaired equipment is restored to normal working order, the impairment coordinator shall verify that the following procedures have been implemented:

(1) Any necessary inspections and tests have been conducted to verify that affected systems are operational. The appropriate chapter of this standard shall be consulted for guidance on the type of inspection and test required.
(2) Supervisors have been advised that protection is restored.
(3) The fire department has been advised that protection is restored.
(4) The property owner or designated representative, insurance carrier, alarm company, and other authorities having jurisdiction have been advised that protection is restored.
(5) The impairment tag has been removed.

[**25:**15.7]

Annex A Explanatory Material

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

A.1.2 No standard can be promulgated that will provide all the necessary criteria for the implementation of hybrid fire-extinguishing systems. Technology in this area is under constant development, and this will be reflected in revisions to this standard. The user of this standard must recognize the complexity of hybrid fire-extinguishing systems. Therefore, the designer is cautioned that the standard is not a design handbook. The standard does not do away with the need for competent engineering judgment to be exercised in the design and application of the hybrid system. It is intended that a designer capable of applying a more complete and rigorous analysis to special or unusual problems shall have latitude in the development of such designs. In such cases, the designer is responsible for demonstrating the validity of the approach.

A.1.5.4.1 It is not intended that the application or enforcement of these values be more precise than the precision expressed.

A.1.5.4.2 Users of this standard should apply one system of units consistently and not alternate between units.

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

A.3.3.7 Hybrid Media. Hybrid media is differentiated from a twin fluid water mist system, which uses water for cooling, vaporization, and inerting. The gas in a twin fluid system does not play a role in the extinguishment process and only serves as a medium for the water to atomize. For twin fluid water mist systems, see NFPA 750.

A.3.3.9 Impairment. The use of the phrase fire protection system or unit is a broad reference to those terms used in this standard and NFPA 25. Some fire protection features are referred to as systems in the installation standards (e.g., sprinkler, standpipe, water spray, foam-water, water mist, and hybrid), or are referred to as units (e.g., fire pumps), and others use neither term (e.g., private service fire mains and water tanks). For the purpose of this standard, the term unit refers to a fire pump and its connections required by NFPA 20, or a water storage tank and its connections required by NFPA 22, or a private service fire main and its connections required by NFPA 24. The use of the term unit in the definitions of impairment, deficiency, critical deficiency, and noncritical deficiency is not referring to an individual component such as a sprinkler, valve, fitting, switch, piece of pipe, and so forth. [**25,** 2017]

Temporarily shutting down a system as part of performing the routine inspection, testing, and maintenance on that system while under constant attendance by qualified personnel, and where the system can be restored to service quickly, should not be considered an impairment. Good judgment should be considered for the hazards presented. [**25,** 2017]

A.3.3.9.1 Emergency Impairment. Examples of emergency impairments might include a ruptured pipe, an operated sprinkler, or an interruption of the water supply to the system. [**25,** 2017]

A.3.3.14.2 Maximum Operating Pressure. The operating pressure to which portions of the hybrid system will be subjected could vary depending on the location of pressure reducing devices on the pipe serving the inert gas supply and various other system specific conditions. The maximum operating pressure is intended to reflect the highest pressure to which each component or section of pipe, including hoses where used, would be subjected.

A.3.3.15.2 Pre-Engineered Systems. These systems have the agent quantity, flow rates, specific pipe size, maximum and minimum pipe lengths, flexible hose specifications, number of fittings, and number, types, and locations of nozzles prescribed by a testing laboratory. All other provisions of this standard are to be followed. Based on actual test fires, the hazards protected by these systems are specifically limited as to type and size by a testing laboratory. Limitations on hazards that are allowed to be protected by these systems are contained in the manufacturer's installation manual, which is referenced as part of the listing.

A.4.1.3 Materials listed are not all inclusive, and hybrid systems might not be appropriate for applications that involve other materials that are not listed. Inappropriate applications are those where the hybrid systems are not effective (increased heat absorption and/or oxygen displacement mechanisms for extinguishment not effective), or where the application of the hybrid media could result in vigorous or violent reactions or the release of hazardous compounds due to reactions with the water contained in the hybrid media.

A.4.2 Hybrid fire-extinguishing systems utilize both inert gas and water to extinguish the fire. The typical inert gas design concentration will reduce the oxygen level to between 12.5 percent and 16 percent. The primary health concern of inhalation of oxygen deficient atmospheres is asphyxiation. For nitrogen and argon, the two inert gases most likely to be used in hybrid systems, the NOAEL is 43 percent (12 percent oxygen) and the LOAEL is 52 percent (10 percent oxygen).

Other considerations with respect to personnel safety when hybrid systems are used include the following:

(1) **Noise**. Discharge of a hybrid system can cause noise loud enough to be startling; however, the noise level is generally not high enough to cause permanent or traumatic injury.
(2) **Turbulence**. Discharge of a hybrid system can cause enough turbulence to move unsecured, light objects.
(3) **Temperature/Visibility**. Discharge of a hybrid can cause reduction in temperature and visibility. Visibility will return to predischarge state when the temperature in the enclosure rises above the dew point temperature.
(4) **Wetting of Surfaces.** When discharged under fire conditions, some or all of the water droplets will evaporate to steam resulting in little or no wetting of surfaces. Some wetting of surfaces, however, is possible particularly if there is little heat present to evaporate the water droplets. Caution is advised when walking on surfaces that might have been wetted by the discharge. Electrical energy could be conducted across wetted surfaces.

A.4.3.4 Many studies have been conducted and technical guidance has been published regarding occupant egress time prediction. One source of such information is the *SFPE Handbook of Fire Protection Engineering*. Various approaches are described that can be used by a designer to calculate the available safe egress time (ASET) from a space protected by a clean agent extinguishing system. The ASET value can then be compared to the required safe egress time (RSET), which is the maximum allowed exposure time limit in 4.3.1 and 4.3.2. The ASET value should be less than the RSET value. If the ASET value is initially determined to be equal to or greater than the RSET value, the facility should be modified so that the ASET value is less than the RSET value. Alternatively, a study involving a timed recording of an egress simulation in the protected space is considered an acceptable means of verifying compliance with the maximum allowed exposure time limits.

A.4.3.5 Subsection 4.3.5 makes reference to limiting concentrations of inert gas agents corresponding to certain values of "sea level equivalent" of oxygen. The mean atmospheric pressure of air at sea level is 760 mm Hg (29.92 in. Hg). Atmospheric air is 21 volume percent oxygen. The partial pressures of oxygen in ambient air and air diluted agent to the limiting sea level concentrations corresponding to permissible exposure times of 5 minutes, 3 minutes, and ½ minute are given in Table A.4.3.5(a).

In 3.3.13.3, sea level equivalent of oxygen is defined in terms of the partial pressure at sea level. The mean atmospheric pressure decreases with increasing altitude, as shown in Table 8.4.1.3. The partial pressure of oxygen is 21 percent of the atmospheric pressure. The concentration of added agent, which dilutes air to the sea level limiting partial pressure of oxygen, is given by

[A.4.3.5]

$$vol\ \% = \frac{(0.21 P_{ATM} - P_{O_2,LIM})}{(0.21 P_{ATM})} \times 100$$

where:

P_{ATM} = local mean atmospheric pressure [mm Hg (in. Hg)]

$P_{O_2,LIM}$ = limiting partial pressure of oxygen corresponding to a sea level exposure time limit [mm Hg (in. Hg)]

The effect of altitude on limiting agent concentrations is given in Table A.4.3.5(b) and Figure A.4.3.5.

A.5.1.1 The water is required to be equivalent in quality to potable water. The particular hazard being protected or the application might dictate a higher quality of water such as distilled, deionized, or demineralized. In these cases, the storage of water and piping must be compatible with the type of water being used. For example, wet bench applications or other applications where contamination of process materials could occur due to the use of ionized water, circulating deionized water should be used.

Table A.4.3.5(a) Oxygen Partial Pressure at Sea Level Corresponding to Exposure Limits Given in 4.3.1 and 4.3.2

Exposure Time (min)	Agent Concentration (vol %)	O_2% at Sea Level	Partial Pressure of O_2 (mm Hg)
Air reference	0	21	159.6
5	43	12.0	91.0
3	52	10.1	76.6
½	62	8.0	60.6

A.5.1.2 Quality of the water and corrosion resistance of the piping materials are critical to achieve system performance. Strainers and filters address the potential debris in piping due to pipe joining methods and corrosion.

There might be installations where strainers at the nozzles are impractical due to environmental conditions or hazards, or accessibility. In such cases, the authority having jurisdiction might choose to approve their omission by specifying or requiring specific quality control over the material selection, procurement, installation, hybrid media, and initial system flow testing.

A.5.1.3.1 The filter or strainer should be installed downstream (on the system side) of all piping that is not corrosion resistant. A filter or strainer with mesh openings meeting the requirements of 5.1.4 should be installed downstream (on the system side) of any reservoirs of stored water or break tank with an air–water interface greater than 1 m^2 (10.8 ft^2).

A.5.2 It is recommended to have and in some instances the authority having jurisdiction might require a reserve quantity of inert gas when the time to recharge the inert gas source will unacceptably impact continuation of operations within the protected space.

Table A.4.3.5(b) Relationship of Altitude to Atmospheric Pressure, Oxygen Partial Pressure in Air, and Limiting Agent Concentration

Altitude Above Sea Level (ft)	P_{ATM} (mm Hg)	O_2 Partial Pressure in Air (mm Hg)	Limiting Agent Concentration (vol %)		
			5 min Exposure $P(O_2)$ = 91 mm Hg	3 min Exposure $P(O_2)$ = 76.6 mm Hg	30 sec Exposure $P(O_2)$ = 60.6 mm Hg
−3,000	840	176.4	48.4	56.6	65.6
−2,000	812	170.5	46.6	55.1	64.5
−1,000	787	165.3	44.9	53.7	63.3
0	760	159.6	43.0	52.0	62.0
1,000	733	153.9	40.9	50.2	60.6
2,000	705	148.1	38.5	48.3	59.1
3,000	679	142.6	36.2	46.3	57.5
4,000	650	136.5	33.3	43.9	55.6
5,000	622	130.6	30.3	41.4	53.6
6,000	596	125.2	27.3	38.8	51.6
7,000	570	119.7	24.0	36.0	49.4
8,000	550	115.5	21.2	33.7	47.5
9,000	528	110.9	17.9	30.9	45.3
10,000	505	106.1	14.2	27.8	42.9

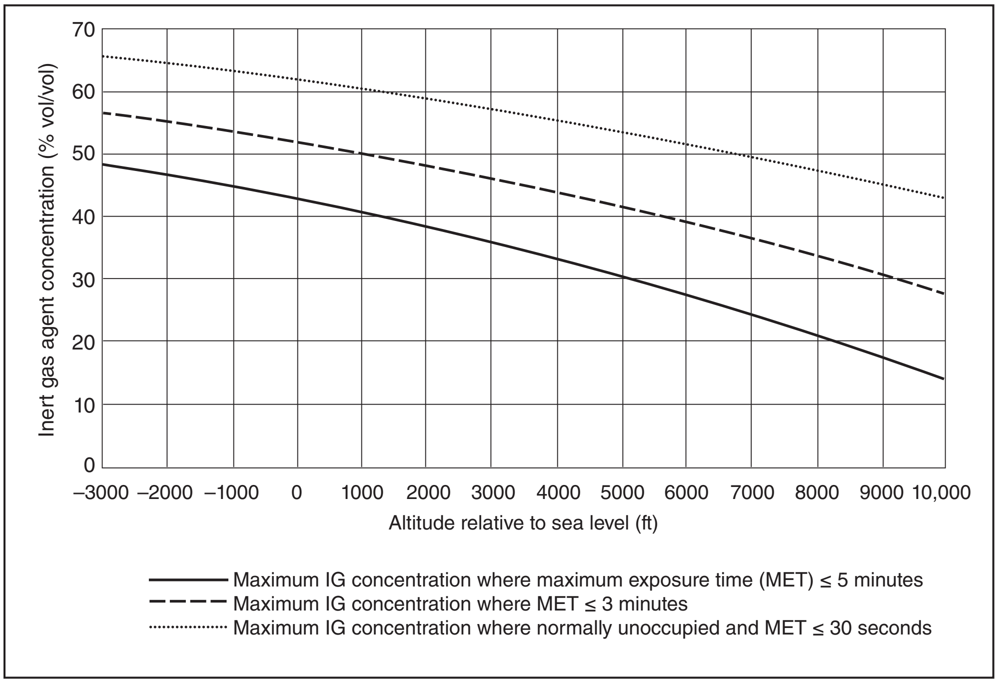

FIGURE A.4.3.5 Inert Gas Limiting Agent Concentrations at Altitude.

A.5.4.2.1 Hybrid systems consist of two agents. Some hybrid systems mix the agents at the container location and use one piping network to carry the hybrid mixture to the nozzle. Other hybrid systems use independent pipe networks to carry the separate agents to the nozzle where they are mixed.

Some plastic pipe materials, such as CPVC and PVC, are not appropriate for use with compressed gases, and the failure mode could be catastrophic. The designer should consider the pipe manufacturer's recommendations for the specific media or agent being used and the maximum service pressure.

A.5.4.3.1 The designer should consider credible failure scenarios that could require pressure relief, such as failure of a pressure regulator, a flow-control valve, or system controls.

A.5.4.4.2.2 Paragraph 5.4.4.2.2 requires that "the thickness of the piping shall be calculated in accordance with ASME B31.1." This does not imply that all the provisions of ASME B31.1 are to be applied. Rather it indicates that the formula for pipe wall thickness shall be used. ASME B31.1 also provides tables of allowable stress values for various metallic pipe materials.

To comply with the requirement of 5.4.4.2.2, the guidelines found in the FSSA *Pipe Design Handbook for Use with Special Hazard Fire Suppression Systems* should be followed. The FSSA *Pipe Design Handbook for Use with Special Hazard Fire Suppression Systems* provides guidance on how to apply ASME B31.1 in a uniform and consistent manner in the selection of acceptable types of pipe and tubing used in special hazard fire suppression systems.

A.5.4.11.2 *FSSA's Pipe Design Handbook for Use with Special Hazard Fire Suppression Systems* provides guidance on pipe hangers and supports, following established industry practices. Additional guidance based on best industry standard practices is found in ANSI/MSS SP-58 for locations where seismic qualification is not required and in MSS SP-127 for locations where seismic qualification is required.

A.5.6.8.2 One objective of predischarge alarms and time delays is to prevent human exposure to atmospheres with oxygen concentrations lower than 19.5 percent. Where a predischarge time delay is required, it should delay the discharge of the system for sufficient time to allow evacuation of personnel from areas within the spaces most remote from the exits.

Hazards associated with fast growth fires would include, but not be limited to, flammable liquid storage or transfer areas and aerosol filling areas.

A.5.6.8.4 Abort switches are a means of delaying automatic agent release. The function of an abort switch should be approved by the authority having jurisdiction. The following two abort functions have been approved by listing agencies. Other abort functions might be possible.

(1) **UL —** A releasing event starts a predischarge timer. If the abort switch is activated, the timer counts down to 10 seconds and holds there. When the abort switch is released, the timer resumes the countdown from 10 seconds and is irreversible.
(2) **IRI —** The abort type functions the same way as the UL type, except that the abort switch will not function unless it is activated before a second input device is activated in a "cross-zone" detection scheme.

A.5.6.9.1 Required auxiliary functions include any functions that must occur to ensure effective control or extinguishment of fire. Examples of required auxiliary functions could be power disconnect, fuel shut-off, HVAC control, damper closure, door closure, and the like.

A.5.6.9.6 Where installations could be exposed to conditions that could lead to loss of integrity of the pneumatic lines, special precautions should be taken to ensure that no loss of integrity will occur.

A.6.1 At the time this standard was developed, system design methods for hybrid extinguishing systems were different between manufacturers and could differ from the methods prescribed in this standard. The relationship between flux density or nozzle spacing and performance in controlling fires is not consistent between systems designed by different manufacturers. Features such as nozzle spacing, flow rate, droplet size distribution, cone angle, and other characteristics need to be determined for each manufacturer's system through full-scale fire testing, representative of the hazard to be protected, to obtain a listing or to be approved for each specific application.

A.6.2 The results of the listing testing should identify the following, as applicable:

(1) System flow rate (minimum and maximum), as follows:
   (a) Flow rate per unit area
   (b) Flow rate per unit volume
   (c) Water-to-inert ratio
(2) System pressure, as follows:
   (a) Nozzle operating pressure range
   (b) Pump/cylinder operating pressure range
   (c) Pump inlet and outlet pressure and flow rate requirements
(3) General water requirements, as follows:
   (a) Quantity/duration
   (b) Quality
   (c) Temperature
(4) General inert gas requirements, as follows:
   (a) Quantity/duration
   (b) Quality
   (c) Temperature
(5) Nozzle characteristics, as follows:
   (a) Type(s)/model number(s)
   (b) Flow rate (minimum and maximum)
   (c) Operating pressure range
(6) Nozzle spray characteristics, as follows:
   (a) Spray angle
   (b) Drop size distribution
   (c) Momentum/velocity
(7) Nozzle installation parameters, as follows:
   (a) Distance above floor (minimum and maximum)
   (b) Distance below ceiling (minimum and maximum)
   (c) Distance above hazard (minimum and maximum)
   (d) Nozzle spacing (minimum and maximum)
   (e) Orientation
   (f) Minimum distance from walls
   (g) Minimum distance from obstructions
(8) Activation device, as follows:
   (a) Type/model number
   (b) Alarm temperature or alarm smoke obscuration level
(9) General design parameters, as follows:
   (a) Pipe sizes and design pressures/wall thicknesses
   (b) Fitting types and design pressures
   (c) Pumps, as follows:
      i. Valves, fittings, and filters
      ii. Power requirements
      iii. Operating pressure and flow rates
      iv. Water requirements
   (d) Cylinders, as follows:
      i. Valves and fittings
      ii. Capacity
      iii. Operating pressures

A.6.2.1 Requirements for complete hybrid extinguishing systems, including fire test protocols, system component test procedures, and the manufacturer's design, installation, operation, and maintenance manual review, have been published in FM 5580. Other listing organizations generally apply their own requirements.

A.6.2.2 The test fire hazard reflects the application specified. Test fires should be chosen such that the performance objective (i.e., fire extinguishment) of the system can be determined. Fire tests are conducted inside an enclosure, as applicable, and test fires should be chosen such that the influence from the enclosure is minimized.

A.6.2.3.2 Enclosure variables include, but are not limited to, height, volume, obstructions, and ventilation. Fire hazard properties include, but are not limited to, fuel type and fuel configuration. Occupancy status is an indication of whether the application is intended to be normally occupied, normally unoccupied, or unoccupiable.

A.6.4.1 The construction of the enclosure should substantially contain the hybrid media in the vicinity of the hazard for a sufficient length of time to achieve the fire protection objectives of the hybrid extinguishing system. As with other water-based systems, consideration should be given to account for the pressure changes developed during the fire and the hybrid media discharge.

A.6.4.1.2.1 Natural ventilation and openings in the enclosure allow the hot gases layer (ceiling jet) to exhaust hybrid media from the compartment, decreasing the extinguishing potential. The flow of gases into and out of the compartment alters the mixing characteristics of the system, which might require the additional momentum of the hybrid media in order to overcome the alteration. Forced ventilation also significantly reduces the amount of hybrid media in the compartment and affects the mixing characteristics of the system.

Prior to or concurrent with the operation of the hybrid extinguishing system, consideration should be given to automatic closing of doors and dampers, shutdown of electrical equipment, and shutdown of HVAC equipment.

A.6.4.1.2.1.1 Examples of such openings include, but are not limited to, doors and windows.

A.6.4.1.2.1.2 Examples of such precautions could include, but are not limited to, automatic door closures and hybrid media curtains.

A.8.2.2 Unclosable openings in the enclosure membrane should not exceed the manufacturer's tested tolerance.

A.8.2.3.1 The effect on the water mist density due to filters or equipment installed in a self-contained recirculating ventilation system should be considered.

A.8.3.1(4) The time to extinguishment is intended to be less than the design discharge time.

A.8.4.1.2 The flooding factor can be calculated in accordance with the following equation:

[A.8.4.1.2]

$$X = \ln\left(\frac{20.95}{C_{oxygen}}\right)$$

where:

X = flooding factor (m^3/m^3)

C_{oxygen} = design concentration of oxygen at 21°C (% vol/vol)

A.8.4.2.1 A shorter time to discharge the minimum volume of inert gas could be more appropriate for a specific hazard. The risk of delayed extinguishment should be weighed against the effects of increasing the system discharge rate (e.g., enclosure pressurization).

A.8.4.3 The calculated number of nozzles could differ from the number required by each nozzle manufacturer's listing or design guidance. Consult each nozzle's manufacturer's manual for area of coverage and any other requirements that could affect the nozzle quantity.

A.8.6.1 Two types of fires can occur in solid fuels: (1) one in which volatile gases resulting from heating or decomposition of the fuel surface are the source of combustion and (2) one in which oxidation occurs at the surface of or in the mass of fuel. The first type of fire is commonly referred to as "flaming" combustion, while the second type is often called "smoldering" or "glowing" combustion. The two types of fires frequently occur concurrently, although one type of burning can precede the other. For example, a wood fire can start as flaming combustion and become smoldering as burning progresses. Conversely, spontaneous ignition in a pile of oily rags can begin as a smoldering fire and break into flames at some later point.

Flaming combustion, because it occurs in the vapor phase, can be extinguished with relatively low levels of hybrid media. In the absence of smoldering combustion, it will stay out. Unlike flaming combustion, smoldering combustion is not subject to immediate extinguishment. Characteristic of this type of combustion is the slow rate of heat losses from the reaction zone. Thus, the fuel remains hot enough to react with oxygen, even though the rate of reaction, which is controlled by diffusion processes, is extremely slow.

Smoldering fires can continue to burn for many weeks — for example, in bales of cotton and jute and heaps of sawdust. A smoldering fire ceases to burn only when either all the available oxygen or fuel has been consumed or the fuel surface is at too low a temperature to react. Smoldering fires usually are extinguished by reducing the fuel temperature, either directly by application of a heat-absorbing medium, such as water, or by blanketing with an inert gas. The inert gas slows the reaction rate to the point where heat generated by oxidation is less than heat losses to surroundings. This causes the temperature to fall below the level necessary for spontaneous ignition after removal of the inert atmosphere.

For the purposes of this standard, smoldering fires are divided into two classes: (1) where the smoldering is not deep seated and (2) deep-seated fires. Whether a fire will become deep seated depends, in part, on the length of time it has been burning before application of the extinguishing agent. This time is usually called the "preburn" time.

Another important variable is the fuel configuration. While wood cribs and pallets are easily extinguished with Class A design concentrations, vertical wood panels closely spaced and parallel can require higher concentrations and long hold times for extinguishment. Fires in boxes of excelsior and in piles of shredded paper also can require higher concentrations and long hold times for extinguishment. In these situations, heat tends to be retained in the fuel array rather than being dissipated to the surroundings. Radiation is an important mechanism for heat removal from smoldering fires.

In order to cool deep-seated fires and to prevent re-ignition of a surface fire, the extinguishing concentration of the hybrid media must be maintained in a defined hazard zone that incorporates the anticipated fire location(s).

A.9.3.2 Test and performance data can be obtained from the manufacturer.

A.9.5.2 Examples of hazards with a mechanical rundown time include ventilation and rotating equipment.

A.9.5.4 Most flammable liquids have a boiling point below the autoignition temperature of the fuel. The maximum temperature of the liquid mass is limited to the boiling point. Some fuels, however, have boiling points above their autoignition temperature. These fuels will burn before they boil, and the temperature of the mass of fuel might continue to rise above the autoignition temperature. The resultant "super-heated" mass of fuel will be subject to re-ignition until the fuel has cooled below its autoignition temperature.

The time required for the temperature of such fuels to drop below the autoignition temperature depends on the mass and configuration of the fuel.

A.11.1.5(15) Critical system application criteria define the design basis of the system. This could include the hybrid media density, target flow rate, or other criteria that are critical to fire extinguishment.

A.11.4 Owner's documentation should provide information to the user or a third party to verify that the system has been designed and installed properly. Manuals also should include operation and maintenance instructions for each piece of equipment or device of the as-built system.

A.11.5.1 Permanent markers do not meet the intent of this requirement, as the ink can degrade over time.

A.12.5.2 Pipe segments should be cleaned prior to installation. After pipe installation, the system should be flushed with water or a compressed gas to remove any remaining debris prior to nozzle installation.

A.12.5.3 It is essential that pipe sealants, tape, or lubricants not be allowed to enter the pipe network. By leaving the first thread on the end of a pipe devoid of sealant, tape, or lubricant, the possibility of these substances entering the pipe network and plugging small orifices in control devices or discharge nozzles is greatly reduced.

A.12.5.7 See Figure A.12.5.7 and Table A.12.5.7.

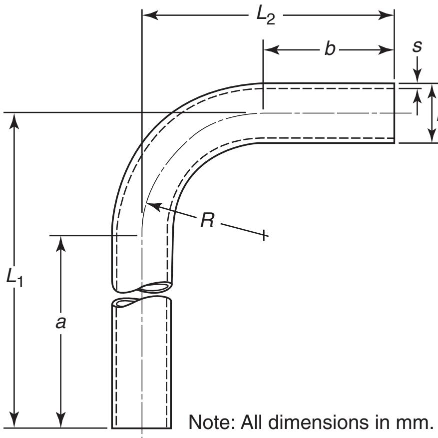

FIGURE A.12.5.7 Installation Measurements for Application of Table A.12.5.7.

A.12.5.8 The FSSA *Pipe Design Handbook for Use with Special Hazard Fire Suppression Systems* provides guidance on pipe hangers and supports, following established industry practices. Additional guidance based on “best industry standard practice” is found in ANSI/MSS SP-58 for locations where seismic qualification is not required or in MSS SP-127 for locations where seismic qualification is required.

A.12.5.8.4.1 A single rigid hanger could be designed to support multiple changes in direction.

A.12.6.4 The strainer or filter can be integral to supplied system components.

A.12.9.2.6 Verification of the connection between the device and the pipe can be achieved by visual inspection or test. Sensors installed in nitrogen piping can be verified by a pneumatic test of the piping system or an abbreviated discharge using inert gas only.

A.12.9.3.2 The pressure test is intended to identify any major leaks in the pipeline that might compromise the proper operation of the system. It is not intended to be a proof pressure test of the strength of the pipeline. The normal operating pressure is the expected pressure in the pipeline during discharge. On systems that have a high-pressure inert gas supply manifold as well as low-pressure piping, the test pressure for the respective sections of pipe should correspond to the normal operating pressure at ambient temperature for that section of pipe.

A.13.1.1 When a hybrid fire-extinguishing system is integrated with other fire protection and life safety systems, NFPA 3 should be referenced for incorporation of the acceptance test into the commissioning plan.

Table A.12.5.7 Recommended Minimum Bending Radii for Different Sizes of Tube

Tube O.D. (mm)	Tolerance± (mm)	Wall Thickness, *S* (mm)	Tube I.D. (mm)	Bending Radius, *R* (mm)	Leg Length (mm) a	Leg Length (mm) b	Length (mm) L_1	Length (mm) L_2	Weight (kg/piece)
16	0.08	2	12	30	200	40	230	70	0.198
18	0.08	1.5	15	36	200	35	236	71	0.178
20	0.08	2	16	36	200	45	236	81	0.268
20	0.08	2.5	15	36	200	45	236	81	0.326
22	0.08	1.5	19	38	200	40	238	78	0.227
22	0.08	2	18	38	200	40	238	78	0.296
25	0.08	2	21	44	200	50	244	94	0.362
25	0.08	2.5	20	44	200	50	244	94	0.442
25	0.08	3	19	44	200	50	244	94	0.519
28	0.08	1.5	25	48	200	50	248	98	0.319
28	0.08	2	24	48	200	50	248	98	0.417
28	0.08	3	22	48	200	50	248	98	0.601
30	0.08	2.5	25	50	200	60	250	110	0.575
30	0.08	3	24	50	200	60	250	110	0.677
30	0.08	4	22	50	200	60	250	110	0.869
35	0.15	2	31	60	200	65	260	125	0.586
35	0.15	3	29	60	200	65	260	125	0.852
38	0.15	2.5	33	65	200	75	265	140	0.827
38	0.15	3	32	65	200	75	265	140	0.979
38	0.15	4	30	65	200	75	265	140	1.268
38	0.15	5	28	65	200	75	265	140	1.538
42	0.2	2	38	80	200	85	280	165	0.809
42	0.2	3	36	80	200	85	280	165	1.183
50	0.2	6	38	180	150	150	310	310	3.451
65	0.35	10	45	250	160	160	330	330	9.840

A.13.1.3 Where a hybrid fire-extinguishing system operates in conjunction with other building systems, functions, or components, the final testing should be conducted simultaneously with those systems per NFPA 4.

A.13.2.2.3 Proper shielding and grounding is particularly important if ac and dc wiring are combined in a common conduit or raceway.

A.13.2.2.4 Where measuring field circuitry, the following should apply:

(1) All electronic components, such as smoke and flame detectors or special electronic equipment for other detectors or their mounting bases, should be removed.
(2) Jumpers should be installed properly to prevent the possibility of damage within these devices.
(3) All components should be replaced after measuring.

A.13.2.4.1.1 For engineered systems, the pressure at the most remote nozzle should be measured and verified to be in accordance with the manufacturer's specifications.

A.13.2.4.1.2 Alternative test methods could include the following:

(1) Flowing through a dedicated test nozzle
(2) Flowing inert gas through the water supply piping, in lieu of water
(3) Flowing air, in lieu of inert gas or water

A.14.1.1 Any portion or all of the inspection, testing, and maintenance can be permitted to be contracted with an inspection, testing, and maintenance service. When an inspection, testing, and maintenance service company agrees to perform inspections and tests at a specific frequency required by this standard, the inspection, testing, and maintenance service company should perform all inspections and tests that are required more frequently than the specified frequency. For example, the ITM service provider agrees to perform required inspections and tests on an annual basis. Those inspections and tests required on a daily, weekly, quarterly, and semiannual frequency should also be performed during the annual inspections and tests.

A.14.1.8 It is essential that personnel be trained to maintain the specific make and model of the system in accordance with the system manufacturer's guidelines.

A.14.2.2 An inspection of the system is a quick check to give reasonable assurance that the extinguishing system is fully charged and operable. It is done by seeing that the system is in place, that it has not been actuated or tampered with, and that there is no obvious physical damage or condition to prevent operation. This quick check of the system will generally be done by the owner's representative.

A.14.2.4.2 It is essential that personnel be trained to maintain the specific make and model of the system in accordance with the system manufacturer's guidelines.

A.14.3.7 If heat is used for drying, the temperature should not exceed the manufacturer's specification.

A.14.4 One of the major causes of personnel injury and property damage is attributed to the improper handling of agent containers by untrained and unqualified personnel. In the interest of safety and to minimize the potential for personnel injury and property damage, the following guidelines should be adhered to:

(1) If any work is to be performed on the fire suppression system, qualified fire service personnel, trained and experienced in the type of equipment installed, should be engaged to do the work.
(2) Personnel involved with fire suppression system cylinders must be thoroughly trained in the safe handling of the containers as well as in the proper procedures for installation, removal, handling, shipping, and filling; and connection and removal of other critical devices, such as discharge hoses, control heads, discharge heads, initiators, and anti-recoil devices.
(3) The procedures and cautions outlined on the cylinder nameplates and in the operation and maintenance manuals, owner's manuals, service manuals, and service bulletins that are provided by the equipment manufacturer for the specified equipment installed should be followed.
(4) Most fire suppression system cylinders containing agent under pressure are furnished with valve outlet anti-recoil devices and in some cases cylinder valve protection caps. Do not disconnect cylinders from the system piping or move or ship the cylinders if the anti-recoil devices or protection caps are missing. Obtain these parts from the distributor of the manufacturer's equipment or the equipment manufacturer. These devices are provided for safety reasons and should be installed at all times, except when the cylinders are connected into the system piping or being filled.
(5) All control heads, pressure-operated heads, initiators, discharge heads, or other type of actuation devices should be removed before disconnecting the cylinders from the system piping, and anti-recoil devices and/or protection caps should be immediately installed before the cylinders are moved or shipped. Fire suppression system equipment often varies from manufacturer to manufacturer; therefore, it is important to follow the instructions and procedures provided in the specific equipment manufacturer's manuals. The preceding procedures should be undertaken only by qualified fire suppression system service personnel.
(6) Safety is of prime concern. Never assume that a cylinder is empty. Treat all cylinders as if they are fully charged. Inert gas cylinders are under high pressure and can produce high discharge thrusts out of the valve outlet if not handled properly. Remember, pressurized cylinders are extremely hazardous. Failure to follow the equipment manufacturer's instructions and the guidelines contained herein can result in serious bodily injury, death, or property damage.

A.14.7.2 Training should cover the following:

(1) Health and safety hazards associated with exposure to extinguishing agent caused by inadvertent system discharge
(2) Difficulty in escaping spaces with inward swinging doors that are overpressurized due to an inadvertent system discharge
(3) Possible obscuration of vision during system discharge
(4) Need to block open doors at all times during maintenance activities
(5) Need to verify that a clear escape path exists to compartment access
(6) A review of how the system could be accidentally discharged during maintenance, including actions

required by rescue personnel should accidental discharge occur

A.14.8 Needed corrections and repairs should be classified as an impairment, critical deficiency, or noncritical deficiency according to the effect on the fire protection system and the nature of the hazard protected.

Impairments are the highest priority problem found during inspection, testing, and maintenance and should be corrected as soon as possible. The fire protection system cannot provide an adequate response to a fire, and implementation of impairment procedures outlined in Chapter 15 is required until the impairment is corrected.

Critical deficiencies need to be corrected in a timely fashion. The fire protection system is still capable of performing, but its performance can be impacted and the implementation of impairment procedures might not be needed. However, special consideration must be given to the hazard in the determination of the classification. A deficiency that is critical for one hazard might be an impairment in another.

Noncritical deficiencies do not affect the performance of the fire protection system but should be corrected in a reasonable time period so that the system can be properly inspected, tested, and maintained.

Assembly occupancies, health care facilities, prisons, high-rise buildings, other occupancies where the life safety exposure is significant, or facilities that cannot be evacuated in a timely manner require special consideration. As an example, a nonfunctioning waterflow alarm might be considered a critical deficiency in a storage warehouse but an impairment in a hospital.

High hazard occupancies where early response to a fire is critical also require special consideration. A small number of painted sprinklers could be considered an impairment for a system protecting a high hazard occupancy but might be considered a critical deficiency in a metal working shop.

A.14.8.1 System deficiencies not explained by normal wear and tear, such as hydraulic shock, can often be indicators of system problems and should be investigated and evaluated by a qualified person or engineer. Failure to address these issues could lead to catastrophic failure.

A.15.1 The general model for impairment procedures is based on Chapter 15 of NFPA 25. It is recognized that hybrid systems will commonly exist alongside water-based fire protection systems and should follow essentially the same impairment procedures.

A.15.3.1 A clearly visible tag alerts building occupants and the fire department that all or part of the fire protection system is out of service. The tag should be weather resistant, plainly visible, and of sufficient size [typically 100 mm × 150 mm (4 in. × 6 in.)]. The tag should identify which system is impaired, the date and time impairment began, and the person responsible.

A.15.3.2 An impairment tag should be placed on the fire department connection to alert responding fire fighters of an abnormal condition. An impairment tag that is located on the system riser only could go unnoticed for an extended period if fire fighters encounter difficulty in gaining access to the building or sprinkler control room. [**25:**A.15.3.2]

A.15.5 The need for temporary fire protection, termination of all hazardous operations, and frequency of inspections in the areas involved should be determined. All work possible should be done in advance to minimize the length of the impairment. Where possible, temporary feedlines should be used to maintain portions of systems while work is completed.

Fire protection systems should not be removed from service when the building is not in use. Where a system that has been out of service for a prolonged period, such as in the case of idle or vacant properties, is returned to service, qualified personnel should be retained to inspect and test the systems.

A.15.5.2(4)(b) A fire watch should consist of trained personnel who continuously patrol the affected area. Ready access to fire extinguishers and the ability to promptly notify the fire department are important items to consider. During the patrol of the area, the person should not only be looking for fire, but making sure that the other fire protection features of the building such as egress routes and alarm systems are available and functioning properly. [**25:**A.15.5.2(4)(b)]

A.15.5.2(4)(c) Temporary water supplies are possible from a number of sources, including use of a large-diameter hose from a fire hydrant to a fire department connection, use of a portable tank and a portable pump, or use of a standby fire department pumper and/or tanker. [**25:**A.15.5.2(4)(c)]

A.15.5.2(4)(d) Depending on the use and occupancy of the building, it could be enough in some circumstances to stop certain processes in the building or to cut off the flow of fuel to some machines. It is also helpful to implement "No Smoking" and "No Hot Work" (cutting, grinding, or welding) policies while the system is out of service because these activities are responsible for many fire ignitions. [**25:**A.15.5.2(4)(d)]

A.15.6 Emergency impairments include, but are not limited to, system leakage, interruption of water supply, frozen or ruptured piping, equipment failure, or other impairments found during inspection, testing, or maintenance activities. [**25:**A.15.6]

A.15.6.2 When one or more impairments are discovered during inspection, testing, and maintenance activities, the owner or owner's authorized representative should be notified in writing.

A.15.7 Occasionally, fire protection systems in idle or vacant buildings are shut off and drained. When the equipment is eventually restored to service after a long period of not being maintained, it is recommended that qualified personnel or a qualified contractor perform the work.

Annex B Fire Test Methods

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

B.1 General.

B.1.1 The purpose of this annex is to provide a recommended test procedure for determining the inert gas flooding factor, *X*, as described in 8.4.1, for a hybrid nozzle or array of hybrid nozzles used to protect a specific fuel or hazard type with a fixed flow rate of water and a fixed flow rate of inert gas agent.

B.1.2 The characteristics identified in 8.3.1 should be recorded as part of the testing program.

B.1.3 The flooding factor determined in accordance with this method should be applied as a baseline value for fire extinguishment testing during the listing process.

B.2 Flooding Factor.

B.2.1 The inert gas flooding factor, *X*, for a specific fuel or hazard type to be protected by a hybrid nozzle or system should be established through testing.

B.2.2 The inert gas flooding factor at sea level should be determined in accordance with the following equation:

[B.2.2]

$$X = \frac{V_{inert\ gas}}{ACF \cdot V_{enclosure}}$$

where:

X = flooding factor at sea level and 21°C (70°F) ambient temperature [m^3/m^3 (ft^3/ft^3)]

$V_{inert\ gas}$ = volume of inert gas component of the discharged hybrid media [m^3 (ft^3)]

$V_{enclosure}$ = volume of the test enclosure [m^3 (ft^3)]

ACF = atmospheric correction factor from Table 8.4.1.3 for the elevation of the test enclosure

B.2.3 The flooding factor, *X*, as determined by the manufacturer for Class A fires should be validated based on all tests recommended in Section B.4.

B.2.4 The flooding factor, *X*, as determined by the manufacturer for Class B fires should be validated based on all tests recommended in Section B.5.

B.3 General Test Parameters.

B.3.1 Extinguishment. The primary criteria should be complete extinguishment of fire within the test enclosure.

B.3.1.1 For Class A fire tests, both of the following criteria should be observed:

(1) The fire is extinguished before the end of discharge.
(2) Flaming combustion does not reignite after the enclosure is ventilated in accordance with B.4.4.

B.3.1.2 For Class B fire tests, fires should be extinguished in less than 30 seconds after the end of discharge.

B.3.2 Discharge Time. The hybrid media should be discharged within 180 seconds, or in accordance with the manufacturer's design discharge time.

B.3.3 Conditioning.

B.3.3.1 Hybrid media components, including nitrogen cylinders and water supply, should be conditioned to 21°C ± 3°C (70°F ± 5°F) prior to the test fire.

B.3.3.2 The enclosure should be maintained at 21°C ± 3°C (70°F ± 5°F) prior to the ignition of the test fire.

B.3.4 Enclosure.

B.3.4.1 Testing should be conducted in an enclosure having a volume equal to the maximum spacing and protected volume for the quantity of nozzles used.

B.3.4.2 The test enclosure should have a volume no less than 100 m^3 (3530 ft^3).

B.3.4.3 The test enclosure should have unclosable openings, such that the total open area represents the manufacturer's maximum specified limit for the system or nozzle.

B.3.4.3.1 At least 40 percent of the open area should be located 305 mm (12 in.) or less below the ceiling.

B.3.4.3.2 At least 40 percent of the open area should be located 305 mm (12 in.) or less above the floor.

B.3.5 Extinguishing System.

B.3.5.1 The extinguishing system should be assembled such that the nozzle(s) operates at the manufacturer's specified conditions, including minimum operating pressure and minimum discharge rate of water.

B.3.5.2 Where multiple nozzles are used, nozzles should be evenly distributed throughout the enclosure in accordance with the manufacturer's design manual.

B.3.6 Fuel Location. The test fuel should be located where it will minimize the effects of local application.

B.4 Tests with Class A Fuels.

B.4.1 Test Fuels. Class A fuels used for testing should comprise three wood cribs and three polymeric material fuel arrays for each of the three polymeric materials.

B.4.1.1 Wood Crib.

B.4.1.1.1 The wood crib should be assembled from four layers of six trade size 50 mm × 50 mm × 450 mm (2 in. × 2 in. × 18 in.) long kiln spruce or fir lumber having a moisture content between 9 and 13 percent.

B.4.1.1.2 The individual wood members in each layer should be evenly spaced, forming a square determined by the specified length of the wood members.

B.4.1.1.3 Alternate layers of the wood members should be placed at right angles to one another.

B.4.1.1.4 The wood members forming the outside edges of the crib should be stapled or nailed together.

B.4.1.1.5 Ignition of the crib should be achieved by the burning of commercial grade heptane in a square steel pan 0.23 m^2 (2.5 ft^2) in area and not less than 101.6 mm (4 in.) in height.

B.4.1.1.6 The heptane fire should burn for 3 to 3½ minutes; approximately 0.95 L (¼ gal) of heptane will provide a 3 to 3½ minute burn time.

B.4.1.1.7 The crib should be centered with the bottom of the crib 304 mm to 609.6 mm (12 in. to 24 in.) above the top of the pan and the test stand should be constructed such that the bottom of the crib is exposed to the atmosphere.

B.4.1.1.8 Once the heptane is ignited, the crib should be allowed to burn freely for approximately 6 minutes outside the test enclosure.

B.4.1.1.9 Just prior to the end of the preburn period, the crib should be moved into the test enclosure and centered on a stand such that the bottom of the crib is between 508 mm and 711 mm (20 in. and 28 in.) above the floor.