

# NFPA<sup>®</sup>

# 770

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

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## 2021



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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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**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

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

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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 <sup>2</sup> | square feet            | ft <sup>2</sup> |
| 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 <sup>3</sup> | cubic feet             | ft <sup>3</sup> |
| 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  $D_v$ .** 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  $\mu\text{m}$  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) Predischage alarm
- (2) Predischage 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.    |
|------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>Copper Tube (Drawn, Seamless)</b>                                                                                         |                 |
| <i>Standard Specification for Seamless Copper Tube*</i>                                                                      | ASTM B75/B75M   |
| <i>Standard Specification for Seamless Copper Water Tube*</i>                                                                | ASTM B88        |
| <i>Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube</i>                     | ASTM B251/B251M |
| <b>Stainless Steel</b>                                                                                                       |                 |
| <i>Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service</i>                  | ASTM A269/A269M |
| <i>Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service</i> | ASTM A632       |
| <i>Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products</i>                             | ASTM A778/A778M |
| <i>Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service</i>         | ASTM A789/A789M |
| <i>Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</i>                 | ASTM A312/A312M |
| <b>Galvanized Steel Pipe</b>                                                                                                 |                 |
| <i>Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless</i>                        | ASTM A53/A53M   |
| <i>Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service</i>                                    | 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  $\mu\text{m}$  (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).

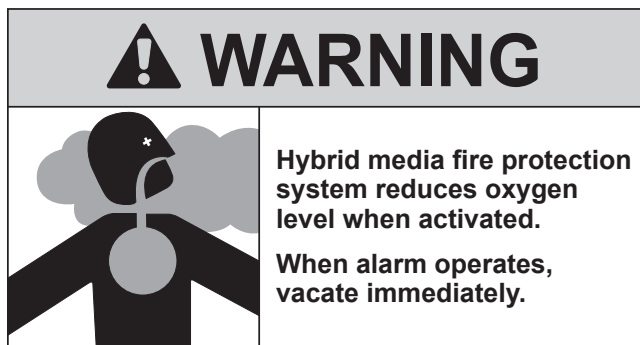


FIGURE 5.6.8.6.2(a) Sign in Every Protected Space.

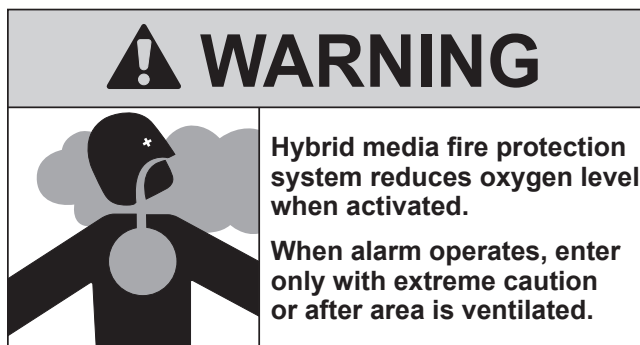


FIGURE 5.6.8.6.2(b) Sign at Every Entrance to Protected Space.

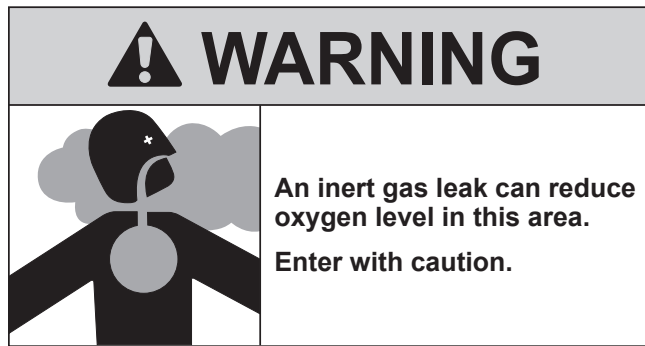


FIGURE 5.6.8.6.2(c) Sign at Every Entrance to Inert Gas Storage Rooms or Areas where Inert Gas Could Collect in the Event of a Discharge from a Safety Device or Control Panel Leak.

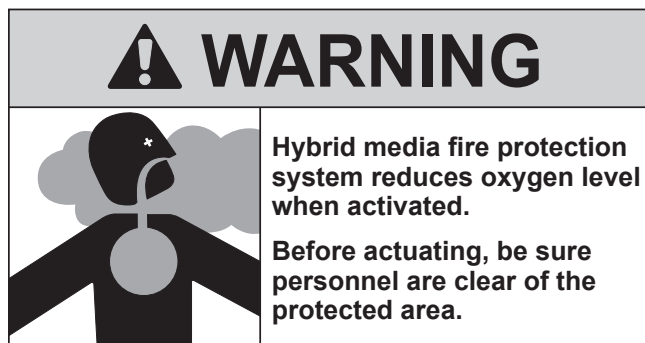


FIGURE 5.6.8.6.2(d) Sign at Every Remote Manual Actuation Station.

### 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.